THE JOURNAL OF
Engineering Education

March, 1955 Vol. 45, No. 7

LIBRARY
COLLEGE OF ENGINEERING

Contents for March

Do You Know 499
The Pennsylvania State University, College of Industry and Agriculture 501
The Creative Process ..... *E. K. Von Fange* 508
The Creative Engineering Program ..... *C. F. Hix, Jr.* 514
Report of ASEE-General Electric Company Seminar ..... *R. H. Buescher* 519
Engineering Analysis as Training in Ingenuity ..... *D. W. Ver Planck* 523
". . . For Such a Time as This" ..... *W. L. Everitt* 526
Vibration Problems ..... *J. J. Ryan* 531
How Should Exams Be Graded? ..... *R. L. Sanks* 534
Stress the Fundamentals—Applied ..... *D. I. Cook* 538
Teaching Tips—
Conference Method in Lab Courses ..... *J. E. Gibson* 540
UPADI—What It Is, What It Does 542
James H. McGraw Award 543
Teaching of Engineering Ethics ..... *M. D. Cooper* 545
Manufacturing Process Courses ..... *M. L. Begeman and B. H. Amstead* 547
T-Square Page—
Graphics and Differential Equations ..... *S. A. Coons* 555
Graduate Curriculum in Technical Writing ... *S. P. Olmsted* 557
Engineering Economy and Operations Research *L. G. Mitten* 560
Minutes of Executive Board 564
Teaching Positions Available 567
Section Meetings 570

New Members—567 College Notes—554, 559, 563, 573
In the News—541, 554
Sections and Branches—513, 530, 566

The American Society for Engineering Education

Used by colleges and universities from coast to coast—just a sampling of 1954-55's users

University of Tulsa
Louisiana Polytechnic Institute
Arlington State College
University of New Mexico
Arizona State College
Kilgore Junior College
New Mexico State College of Agriculture and Mechanic Arts
Louisiana State University
Sam Houston State Teachers College
University of Oklahoma
Odessa College
Rice Institute
Amarillo College
Agricultural and Mechanical College of Texas
University of Southern California
Clark College
Montana State College
Portland State College
Montana School of Mines
Central State College (Ohio)
Lake Forest College
Kansas State Teachers College
Lawrence Institute of Technology
Colorado School of Mines
South Dakota State College
University of Colorado
University of Minnesota
Western Reserve University
Michigan State College
Drury College
Findlay Engineering College
Rose Polytechnic Institute
Illinois Institute of Technology
University of Kentucky
University of Toledo
Florida State University
Lincoln Memorial University
Christian Brothers College
Memphis State College
University of Tennessee
Perkinston Junior College
University of Chattanooga
University of Miami
Alabama Agricultural and Mechanical College
Mississippi State College
Rensselaer Polytechnic Institute
Rutgers University
University of Virginia
Pennsylvania State University
Syracuse University
University of Maryland
College of William and Mary
Virginia Polytechnic Institute
Tufts College
University of Maine

Outstanding in the field

TECHNICAL DRAWING

Third Edition

by

Frederick E. Giesecke
Alva Mitchell
& Henry C. Spencer

Clarity and completeness in all fundamentals *plus* a wealth of practical information have made this book outstanding in the field of technical drawing

1949 851 pp. $6.00

Accompanying Books

TECHNICAL DRAWING PROBLEMS

second edition

by **Giesecke, Mitchell & Spencer**

1947 105 pp. and 105 blanks $4.80

TECHNICAL DRAWING PROBLEMS

Series Two

by **Spencer & Grant**

1948 138 sheets $5.00

The Macmillan Company

60 Fifth Ave., N.Y. 11, N.Y.

TANG

Alternating-Current Circuits

Partial List of 1954–55 Adoptions

Catholic University
Cornell University
Drexel Institute of Technology
Louisiana State University
New York University
Ohio State University
RCA Institutes
Rensselaer Polytechnic Institute
Rice Institute
Seattle University
State College of Washington
University of Akron
University of Buffalo
University of California
University of Connecticut
University of Detroit
University of Minnesota
University of Nevada
University of Southern California
University of Tennessee
University of Texas
University of Toronto
University of Vermont
University of Washington

INTERNATIONAL TEXTBOOK COMPANY

Scranton 9, Pennsylvania

THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION
OFFICERS FOR 1954–55

President: N. W. DOUGHERTY, Dean of Engineering, University of Tennessee, Knoxville Tennessee.

Vice President (general and regional activities): B. R. TEARE, JR., Dean of Engineering an Science, Carnegie Institute of Technology, Pittsburgh, Pennsylvania.

Vice President (instructional division activities); L. J. LASSALLE, Dean of Engineering Louisiana State University, Baton Rouge, Louisiana.

Vice President (Engineering College Administrative Council): W. L. EVERITT, Dean o Engineering, University of Illinois, Urbana, Ill.

Vice President (Engineering College Research Council): H. K. WORK, Director of Researc Division, New York University, New York 53, New York.

Treasurer: G. W. FARNHAM, The Ronald Press Company, New York, New York.

Secretary: W. L. COLLINS, University of Illinois, Urbana, Ill.

Editor of the Journal and Assistant Secretary: C. E. WATSON, Northwestern Uni versity, Evanston, Illinois.

Executive Office Secretary: MARION STROHM, Northwestern University, Evanston, Ill.

Office Secretaries: NAOMI GARMAN and LOUISE CHAMBLISS, University of Illinois Urbana, Ill.

Junior Past Presidents: L. E. GRINTER, W. R. WOOLRICH, S. C. HOLLISTER.

REPRESENTATIVES ON THE GENERAL COUNCIL

REPRESENTING DIVISIONS

Aeronautical—G. MURPHY
Agricultural—R. H. DRIFTMIER
Architectural—P. E. SONESON
Chemical—J. S. WALTON
Civil—A. J. MCNAIR
Cooperative Engineering Education—H. C. MESSINGER
Educational Methods—A. P. COLBURN
Electrical—H. E. HARTIG
Engineering Drawing—R. S. PAFFENBARGER
English—C. A. BROWN
Evening Engineering Education—R. VAN HOUTEN
Graduate Studies—N. A. CHRISTENSEN
Humanistic-Social—J. W. SHIRLEY
Industrial—F. F. GROSECLOSE
Mathematics—H. K. JUSTICE
Mechanical—E. E. AMBROSIUS
Mechanics—G. N. COX
Mineral—W. J. RUNDLE
Physics—G. P. BREWINGTON
Relations with Industry—G. D. LOBINGIER
Technical Institutes—H. P. RODES

REPRESENTING SECTIONS

Allegheny—E. B. SNAVELY
Illinois-Indiana—N. A. PARKER
Kansas-Nebraska—M. A. DURLAND
Michigan—R. H. SCHOONOVER
Middle Atlantic—T. SAVILLE
Missouri-Arkansas—L. E. STOUT
National Capitol—H. H. ARMSBY
New England—G. A. MARSTON
North Midwest—F. KEREKES
Ohio—N. D. THOMAS
Pacific Northwest—E. R. WILCOX
Pacific Southwest—R. E. VIVIAN
Rocky Mountain—A. DIEFENDORF
Southeast—R. L. SUMWALT
Southwest—M. R. LOHMANN
Upper New York—R. F. EISENBEIS

Society Headquarters: Northwestern University, Evanston, Illinois

ANNUAL MEETING—PENNSYLVANIA STATE UNIVERSITY
State College, Pa. June 20–24, 1955

Published monthly (except during July and August) at Prince and Lemon Sts., Lancaster, Pa., by the American Society for Engineering Education under the Supervision of the Publication Committee: A. B. Bronwell, Chairman, L. E. Grinter, N. W. Dougherty, F. M. Dawson, G. W. Farnham, E. A. Walker, C. E. Watson, Editor. Entered as second class matter, October 17, 1912, at the Post Office at Lancaster, Pa., under the act of August 12, 1912. Subscription Price, $6.00 per year; Yearbook Issue, $6.00; Single Copies, $1.25.

Design of Machine Elements

by **Virgil M. Faires**

Emphasizing the adaptation of theory to practical design, this revised text develops the newer aspects of the subject and features new design information for nearly every machine element. An excellent fifteen page index is included. (The new edition of *Problems on Design of Machine Elements* will be ready for the summer term.) *Published in February. 550 pp., $7.50*

Basic Theory in Electrical Engineering

by **R. G. Kloeffler & E. L. Sitz**

A concise but thorough introduction to the field, this text treats, in logical order, the electrical units, the electrical circuit, electric power, conductors, semiconductors, insulators, magnetostatics, the magnetic circuit, and electrostatics. The mks system is used throughout. *Ready in the spring*

Circuits and Networks

by **Glenn Koehler**

For students in both the power and communications fields, this text covers general network analysis, and applications of circuits and networks in the general field of electrical engineering. *1955, 350 pp., $6.50*

Electrical Elements of Power Transmission Lines

by **Herbert B. Dwight**

An up-to-date treatment of the main elementary propositions and calculations used by power engineers for heavy electrical lines transmitting electric power at high voltage. *1954, 188 pp., $4.25*

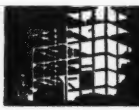
Electrical Transients

by **L. A. Ware & G. R. Town**

This text enables the student to obtain a firm grasp of the principles involved in the action of electrical circuits under transient conditions. *1954, 222 pp., $4.75*

The Macmillan Company

60 FIFTH AVENUE, NEW YORK 11, N.Y.



CHEMICAL ENGINEERING COST ESTIMATION

By Robert S. Aries, R. S. Aries & Associates; and Robert D. Newton, Charles Pfizer & Company, Inc. *McGraw-Hill Chemical Engineering Series.* Ready in July

This new text outlines the principles of cost estimation and evaluation, and provides quantitative data for application of the techniques discussed for resolution of problems encountered in modern industrial practice. Its all-inclusive scope covers the deviation of the individual components of investment, cost, and profit, their interrelationships, quantitative measure, and application. Illustrative problems are included.

INTRODUCTION TO CHEMICAL ENGINEERING

By Walter L. Badger and J. T. Banchero. *McGraw-Hill Chemical Engineering Series.* Ready for fall classes

Presents a discussion of the unit operations of chemical engineering, covering both theory and practice. The theory is developed from the simplest considerations, but in a rigorous manner. An earnest attempt has been made to classify the various types of equipment used in the chemical industries and, so far as possible, to coordinate theory with design.

PROCESS ENGINEERING ECONOMICS

By Herbert E. Schweyer, University of Florida. Ready in June

A simple, teachable text that explains the practical use of cost data in evaluating the economic feasibility of processes, based on theoretical economy principles. Covers a brief, but rigorous, treatment of theoretical engineering economy equations, a concise coverage of the uses of accounting data including cost estimates and evaluations of the economic feasibility of operations, and a comprehensive study of economic balance in order to determine the optimum range for operations at lowest cost.

AUTOMATIC FEEDBACK CONTROL SYSTEM SYNTHESIS

By John G. Truxal, Purdue University. 694 pages, $12.50

This graduate-level development demonstrates the manner in which the feedback and network theory of the electrical engineer combines with the complex function theory and Laplace transform theory of the mathematician to form the theoretical basis for the relatively new field of systems or control engineering. Here is a complete, up-to-date presentation of the methods useful in the design of feedback systems.

Send for copy approv

McGRAW - HILL
330 West 42nd Street

MECHANISM

By JOSEPH S. BEGGS, University of California, Los Angeles. *McGraw-Hill Series in Mechanical Engineering.* Ready for fall classes

Written for courses in advanced kinematics. The choice of notation and the use of the canonical vector equations of relative velocity and acceleration offer the student an almost standard approach to the analysis of mechanism, and result in the rapid facility and understanding in solving complex problems in mechanism. A glossary of terms is included in an appendix.

MACHINE DESIGN

By PAUL H. BLACK, Ohio University. New Second Edition. Ready for fall classes

As a textbook for courses and a reference book for design offices, its purpose is to acquaint the student and engineer with the design of machine elements and the design and selection of units of power transmission, all incorporating optimum characteristics of strength, rigidity, wear and economy of manufacture and operation. The rational approach is used wherever possible, and methods are developed to use advanced information where it is applicable. The revision includes many new figures, new problems, and worked-out examples.

ENGINEERING METALLURGY

By L. F. MONDOLFO, Illinois Institute of Technology; and OTTO ZMESKAL, University of Florida. Ready for fall classes

Blending theory and practice in a simple, comprehensible textbook approach and style, this work offers a unique treatment of the subject. While detailed descriptions of methods and operations are given, the emphasis is on the theoretical reasons behind the operations. Rather than cataloging the properties of individual metals, the underlying unity of the behavior of metals is brought out, thus simplifying the understanding of how and why metals behave as they do. Principles of casting, the physics of metals and plastic working practices are thoroughly treated.

FARM MACHINERY AND EQUIPMENT. New Fourth Edition

By HARRIS P. SMITH, A. & M. College of Texas. *McGraw-Hill Publications in Agricultural Engineering.* 528 pages, $7.50

This best-selling book on all the types of equipment used in producing, handling, and processing farm crops is completely revised to eliminate all obsolete material and include the most recent developments. A new chapter on lubricants and lubrication incorporates the American Petroleum Institute's latest classification of engine oils. Modern methods of weed control and the application of liquid and gas fertilizers are examined. Materials on primary and secondary tillage, tillage history, and up-to-date information on the handling of specific crops are included.

for copy approval

BOOK COMPANY
New York 36, N. Y.

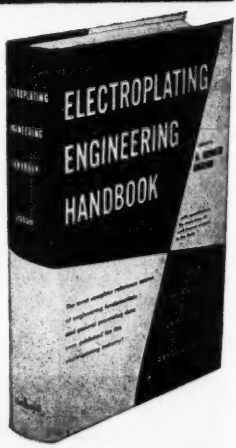
A complete, up-to-date reference book for all engineering students . . .

ELECTROPLATING ENGINEERING HANDBOOK

edited by A. KENNETH GRAHAM, President, Graham, Crowley & Associates, Inc., in collaboration with more than 40 widely known authorities in the electroplating field.

In the 784 fact-packed pages of this comprehensive new handbook you can quickly find the answer to practically every imaginable engineering and processing problem relating to electroplating and metal finishing! It contains all of the most recent authentic information on processing and operating techniques.

Full chapters, complete with charts, tables and drawings, cover such important topics as: the design of parts to be plated; metals surface preparation; standards and specifications; processing sequences; testing of deposits; metallurgy; trouble-shooting; water requirements; waste treatment; industrial hygiene and safety; plant location and layout; construction of foundations and floors; design and installation of tanks, linings, barrels and racks; heating and cooling equipment; anode and cathode rod and bus bar systems; exhaust systems; manual, semi-automatic and fully automatic plating machines; current sources; filtration; rinsing and drying; auxiliary plating room equipment; general maintenance; and many others.



1955 784 pages Profusely illustrated
$10.00

Subject to special educational discount

Write for your FREE EXAMINATION copy today.

REINHOLD PUBLISHING CORPORATION

Dept. M-759
430 Park Avenue New York 22, N. Y.

Prentice-Hall

TOOL DESIGN

By WILLIAM R. JEFFRIES, *Montana State College*

- In concise and easily readable form, here is all the material needed for an introductory course on the principles and practices of tool design.
- The author has stressed basic principles and his examples have been chosen with this in mind. Ample references guide the student to detailed pursuit of any topics of special interest.
- Clarity of instruction is achieved through a step-by-step development of designing methods. All illustrations are carefully related to the text.
- Topics include the design of machine tool jigs and fixtures, weld and assembly fixtures, punch press tooling, and hydraulic press tooling. Pressworking machines and tools are also described. There is an entire chapter on clamps and methods of clamping and locating.

About 240 pp. . 5⅝ x 8⅛ . April 1955

ELECTRONICS CIRCUITS

By THOMAS L. MARTIN, JR., *University of Arizona*

This new text is a complete course in electronic circuitry, containing important aids designed to ease the teacher's job. Principles of formulation are described and illustrated for many special cases. The technique of deriving design equations is stressed. Contents range from general theory . . . analysis of class "A" circuits . . . oscillators . . . to principles of modulation . . . wave shaping . . . trigger circuits. Ample material is included to lead to the design of the circuit under discussion.

768 pages . 5⅝" x 8⅜" . Published March, 1955

In the PRENTICE-HALL ELECTRICAL ENGINEERING SERIES,
W. L. EVERITT, *Editor*

PRINCIPLES OF COMMUNICATION SYSTEMS

By W. D. HERSHBERGER, *University of California at Los Angeles*

In this new text the fundamental principles and concepts found in all communications systems are treated and their application to specific systems is then shown. The systems considered are diverse in signal spectra, in information rate, and other characteristics.

No book at other than a highly specialized level is available which treats the concepts common to all communications systems, such as noise, information theory, and spectral analysis.

283 pages . 5⅝ x 8⅛ . Published March, 1955

In the PRENTICE-HALL ELECTRICAL ENGINEERING SERIES,
W. L. EVERITT, *Editor*

WATERHAMMER ANALYSIS

By JOHN PARMAKIAN, *Bureau of Reclamation*

Here is a new text containing the newest thought in the whole field of waterhammer analysis. Introductory chapters deal with rigid and elastic watercolumn theories. Another chapter is devoted to the velocity of waterhammer waves in various types of conduits. Many solutions are given using graphical analysis. Methods are presented for including effects of pipe-line friction losses and velocity head, as well as ways to solve compound pipe systems.

192 pages . 6" x 9" . Published February, 1955

In the PRENTICE-HALL CIVIL ENGINEERING & ENGINEERING MECHANICS SERIES,
N. M. NEWMARK, *Editor*

Send for your copies today

p-h PRENTICE-HALL, INC. 70 FIFTH AVENUE, NEW YORK 11

Still the leading

CURRENT ADOPTIONS

SEARS *and* ZEMANSKY COLLEGE PHYSICS (without calculus)

Academie Commerciale (Canada)
Academy of Aeronautics
Alabama Agric. & Mech. College
Alabama St. Teachers College
University of Alberta (Canada)
Alfred University
Aleppo College (Syria)
American Col. for Girls (Turkey)
American University
American Univ. of Beirut (Lebanon)
Arizona State College
University of Arizona
Auburn Community College
Baltimore Junior College
Board of Educ., Alpena, Mich.
Brandeis University
Brigham Young University
Brown University
California St. Polytechnic Col.
Univ. of California, Berkeley
Univ. of California, Riverside
Canisius College
Capital University
Carleton College
Carbon College
Case Institute of Technology
City College of New York
Clarkson College of Technology
University of Colorado
Teachers Col. of Connecticut
Consolidated Vultee Aircraft Div.
Cornell College
Cornell University
Dalhousie University (Canada)
University of Denver
DePauw University
Duke University
Eastern Illinois State College
East Tennessee State College
Eastern Washington Col. of Educ.
Fenn College
George Pepperdine College
Georgetown University
Gettysburg College
Gonzaga University
Hamilton College
Hunter College
Idaho State College
Illinois College
Illinois Wesleyan University
Independent Sch. Dis. of Keokuk, Ia.
Indiana Technical College
Indiana University
James Milliken University
John Carroll University
Johns Hopkins University
Kalamazoo College
Kansas State College
University of Kansas
Keystone Junior College
Kings College
Lassen Junior College
Lawrence College
Lawrenceville School
Lehigh University
Lewis Col. of Science & Technology
Lowell Institute
Lowell Technological Institute
Loyola College
Memorial Univ. of Newfoundland (Canada)
Merrimack College
Michigan State Normal College
University of Michigan
Milwaukee Vocational School
University of Minnesota
Missouri Valley College
Mitchell College
Moberly Junior College
Montana State University
Mount Pleasant Tech. High School
New Mexico Highlands University
New York State Maritime College
New York University
Newark College of Engineering
North Carolina College at Durham
Northwestern University
University of North Dakota
University of Nevada
University of New Mexico
Oceanside-Carlshad College
Oglethorpe University
Oklahoma City University
Our Lady of the Lake College
Oregon State College
University of Ottawa
Otterbein College
Pennsylvania Military College
University of Pennsylvania
Phillips University
Pomona College
Pueblo Junior College
Purdue University
University of Richmond
University of Rochester
Rockhurst College
Roosevelt University
St. Bede College
St. Joseph's College (Pa.)
St. Lawrence University
St. Louis University
St. Michael's College
College of St. Theresa
College of St. Thomas
San Antonio College
San Bernardino Valley College
San Diego State College
San Luis Obispo College
Seattle University
Snow College
Southwestern Louisiana Institute
Southwestern at Memphis
Southwestern University
Stephen F. Austin State College
Taiwan Teachers College
National Taiwan University
Temple University
Tennessee Polytechnic Institute
Texas College of Arts & Industries
University of Texas
U. S. Coast Guard Academy
Upsala College
Utah State Agricultural College
Vanderbilt University
Vassar College
Virginia State College
Washington College (Md.)
Washington & Jefferson College
University of Washington
Wesleyan University
West Virginia Institute of Tech.
William Jewell College
University of Wisconsin
Worcester Polytechnic Institute
University of Wyoming
Xavier Junior College
Xavier University

*Cloth, 912 pp., 727 illus., 2nd ed., 2nd ptg., 1953 $10.00 ($8.50)**

**Indicates college adoption price, five or more copies for classroom use.*

ADDISON-WESLEY
CAMBRIDGE 42.

engineering physics textbooks

CURRENT ADOPTIONS

SEARS *and* ZEMANSKY UNIVERSITY PHYSICS (with calculus)

Adelphi College
Albion College
Alfred University
Alma College
American Univ. at Beirut (Lebanon)
Antioch College
Arizona State College
University of Arizona
Ball State Teachers College
Baltimore Junior College
Boise Junior College
Boston University
Bradley University
Brigham Young University
University of California (Riverside)
Carroll College
Case Institute of Technology
Casper Junior College
Chico State College
Christian Brothers College
The Citadel
Clark College
Clarkson College of Technology
University of Connecticut
Cornell University
Dartmouth College
Deep Springs College
University of Delaware
De Pauw University
Drexel Institute of Technology
Drury College
Duquesne University
Eastern Montana Col. of Education
Ecole Polytechnique (Canada)
Florida State University
Fresno State College
Glendale College
Goucher College
Graceland College
Grand Rapids Junior College
Hamline University
University of Hawaii
Hillyer College
Howard University
University of Idaho
Illinois College
Illinois Institute of Technology
University of Illinois
International Christian Col. (Japan)
State University of Iowa
Joplin Junior College
University of Kentucky
Kenyon College
Lehigh University
Lewis and Clark College
Los Angeles Valley Jr. College
McMaster University (Canada)
University of Maryland
Middlebury College
Milwaukee Institute of Technology
University of Missouri
Monterey Peninsula College
Mt. Holyoke College
Mt. Royal College (Canada)
Mt. St. Louis Institute (Canada)
Mt. San Antonio College
University of New Hampshire
New Jersey St. Tchrs. Col., Trenton
New Mexico Col. of A. & M. A.
New Mexico Inst. of Mining & Tech.
New York State Maritime College
Northwestern University
University of Notre Dame
Oberlin College
Oceanside-Carlsbad College
University of Oklahoma
Olympic College
Orange Coast College
Otterbein College
Pennsylvania State University
Philadelphia Textile Institute
University of Pittsburgh
Pratt Institute
Principia College
Rensselaer Polytechnic Institute
Rose Polytechnic Institute
Rutgers University
Sacramento Junior College
St. Joseph's College
St. Mary's College
College of St. Thomas
Sam Houston State Tchrs. Col.
San Bernardino Valley College
San Diego State College
University of San Francisco
Santa Maria Junior College
University of Scranton
Sir George Williams Col. (Canada)
Smith College
South Dakota State Col. of A. & M.
Southwest Texas Junior College
Stevens Institute of Technology
Syracuse University
University of Tennessee
Texas College of Arts & Industries
Thiel College
University of Toledo
Trenton Junior College
Trinity College
Tulane University
Tuskeegee Institute
U. S. Air Force Inst. of Technology
U. S. Coast Guard Academy
U. S. Naval Academy
U S. Naval Group, Derince, Turkey
Utah State Agricultural College
University of Utah
Utica College
Vanderbilt University
Villanova University
University of Virginia
University of Washington
Washington and Jefferson College
West. Contra Costa Jr. Col.
West Virginia University
West Virginia Wesleyan College
University of Wisconsin
Wittenberg College
Worcester Polytechnic Institute

Cloth, 915 pp., 847 illus., Second Edition 1955 $10.00 ($8.50)*

YOU CANNOT GO WRONG WITH THESE TRIED AND TESTED BOOKS

PUBLISHING COMPANY, INC.
MASSACHUSETTS

For a two-year engineering physics course

Partial List of Adoptions

By Francis Weston Sears, *Massachusetts Institute of Technology*

MECHANICS, HEAT, AND SOUND

American Univ. at Cairo (Egypt)
Bakersfield College
Baylor University
Bowling Green Col. of Commerce
Univ. of Calif., Berkeley, Davis, Los Angeles, Santa Barbara
Chaffey Junior College
University of Chicago
City College of San Francisco
Clarence W. Pierce School of Agr.
Col. Militaire Royale de St. Jean (Canada)
Compton Junior College
East Contra Costa College
East Los Angeles Junior College
El Camino College
Fournier Institute of Technology
Fullerton Junior College
Universidad de la Habana (Cuba)
Humboldt State College
Instituto Technologico de Guadalajara (Mexico)
Instituto Technologico de Monterrey (Mexico)
Kansas Wesleyan College
Knox College
Lake Forest College
Linfield College
Long Beach City College
Long Beach State College
Los Angeles City College
Los Angeles Harbor Junior College
University of Manitoba
College of Marin
Massachusetts Institute of Tech.
Modesto Junior College
University of Montreal
University of New Hampshire
New Mexico Col. of A. & M.A.
University of Notre Dame
Olivet College
Universidad de Oriente (Cuba)
College of the Pacific
Pacific Union College
Penn. St. Tchrs. Col., Indiana
University of Pennsylvania
Phoenix College
Polytechnic Institute of Brooklyn
Providence College
University of Puerto Rico
Reed College
Reedley College
Ripon College
University of Rochester
Royal Military College (Canada)
Royal Roads Canadian Serv. Col.
St. Lawrence University
San Bernardino Valley College
San Jose State College
San Mateo Junior College
Santa Monica City College
Santa Rosa Junior College
Shasta College
Sierra College
Stockton Junior College
University of Southern California
Southern Oregon College
Temple University
Union College
United College (Canada)
Utica College
University of Washington
Washington and Lee University
Yuba College

527 pp., 492 illus. $8.50 ($7.50)

ELECTRICITY AND MAGNETISM

Allegheny College
Arkansas St. Tchrs. Col., Conway
Bakersfield College
Baylor University
Boston College
Brown University
University of California, Berkeley and Los Angeles
Catholic University
University of Chicago
University of Connecticut
Cooper Union
Cornell University
University of Delaware
East Contra Costa College
East Tennessee State College
Fournier Institute of Technology
Franklin and Marshall College
Friends University
Georgia Institute of Technology
Gettysburg College
Hagerstown Junior College
Holy Cross College
University of Houston
Illinois Wesleyan University
Imperial College (England)
Indiana Technical College
Instituto Technologico de Monterrey (Mexico)
King College
LaSalle College
University of Louisville
Lowell Institute
Marshall College
University of Miami
Michigan Col. of Mining & Tech.
Mississippi College
Mississippi Southern College
New Jersey College for Women
New Mexico Col. of A. & M.A.
New York St. Col. for Tchrs., Albany
North Texas State College
University of Notre Dame
Ohio Wesleyan University
Pacific Union College
Pasadena City College
University of Pennsylvania
Phoenix College
Pratt Institute
Providence College
University of Puerto Rico
College of Puget Sound
Randolph-Macon College
Reed College
Rensselaer Polytechnic Institute
Rice Institute
Ripon College
Roberts Wesleyan College
University of Rochester
St. Benedict's College
St. John Fisher College
Shasta College
Simmons College
University of South Dakota
University of Southern California
Stevens Institute of Technology
Thiel College
Utica College
Virginia Polytechnic Institute
Walla Walla College
Washington and Jefferson College
Wellesley College
Yuba College

434 pp., 318 illus. $8.50 ($7.50)

OPTICS

American Univ. at Cairo (Egypt)
Arkansas St. Tchrs. Col., Conway
Bakersfield College
Baylor University
Boston University
Bowling Green Col. of Commerce
Brown University
California State Polytechnic Col.
University of California, Berkeley, Davis, Los Angeles, Riverside
Central State College (Oklahoma)
Chaffey Junior College
University of Chicago
Colby College
Compton Junior College
Cooper Union
DePaul University
DePauw University
East Contra Costa College
East Los Angeles Junior College
Eastern Illinois State College
Emory University
Findlay College
Fort Hays Kansas State College
Fournier Institute of Technology
Franklin and Marshall College
Fullerton Junior College
Furman University
Georgetown College
Gettysburg College
Gonzaga University
Grove City College
Humboldt State College
Instituto Technologico de Monterrey (Mexico)
John Muir College
Long Beach City College
Manhattanville College
College of Marin
Mercer University
University of Miami
Mississippi College
Modesto Junior College
New Mexico Col. of A. & M.A.
Northeastern St. Col. (Oklahoma)
North Texas State College
University of Notre Dame
Olivet College
Orange Coast College
University of Ottawa
College of the Pacific
Pacific Lutheran College
Pacific Union College
Pasadena City College
University of Pennsylvania
Penn. St. Tchrs. Col., Indiana
Phoenix College
University of Portland
Purdue University
Reed College
University of Rhode Island
Royal Military College (Canada)
St. Mary's University
San Bernardino Valley College
San Mateo Junior College
Wake Forest College
Santa Monica City College
University of Scranton
Stevens Institute of Technology
Texas Southern University
Tufts College
Utica College
University of Virginia
Virginia Polytechnic Institute
Wabash College

369 pp., 286 illus. $8.50 ($7.50)

ADDISON-WESLEY PUBLISHING COMPANY, INC., Cambridge 42, Massachusetts

CASES AND PROBLEMS IN PERSONNEL AND INDUSTRIAL RELATIONS

Edgar G. Williams *and* **John F. Mee,** *both of Indiana University*

THIS NEW CASEBOOK IS PLANNED to add realism and practicality to the formal course in personnel management. Designed to accompany any of the standard textbooks in personnel management, the book is organized so that the case material may be assigned for oral or written work, in classroom or laboratory. Forty-four of the case studies give the student the opportunity to discuss and actively participate in solving personnel problems which have been written around actual situations in business concerns. In seven summary case problems the student is led to think creatively—combine and integrate into a functional whole the various personnel policies and practices he has been studying in the individual cases.

Serves these important needs:

1) Stimulates genuine student interest in personnel relations.
2) Gives greater opportunity for discussion and participation.
3) Supplements personnel management theory with practice.

6 ills., approx. 214 pp. Paper cover

ELEMENTS OF STRUCTURAL ENGINEERING

Ernest C. Harris, *Fenn College*

SHOWS APPLICATION of principles of structural engineering in terms of examples and problems faced by the non-civil engineer. Engineering fundamentals inherent in the original design of buildings are highlighted by analyzing the effect of new electrical and mechanical equipment on safety. *423 ills., tables, 505 pp.*

STRUCTURAL DESIGN IN REINFORCED CONCRETE

Clifford D. Williams, *Patchen and Zimmerman;* **and Charles E. Cutts,** *University of Florida*

A BOOK FOR THE BASIC course in reinforced concrete design. Emphasizes general design principles without detailed analyses of their application to complex structures. Formulas derived and used continuously; problems developed from strength of materials concepts. Special sections on construction methods, pre-stressed concrete, design of circular tanks, compression, etc. *211 ills., tables, 308 pp.*

STATICALLY INDETERMINATE STRUCTURES

Paul Andersen, *University of Minnesota*

DESIGNED FOR THE FIRST course in statically indeterminate structures, book directly relates structural analysis to structural design. Numerical applications of actual design problems are an integral part of the work. Includes a chapter on typical design problems.

370 ills., tables, 318 pp.

THE RONALD PRESS COMPANY, 15 E. 26th St., N. Y. 10

WILEY BOOKS

ANALYSIS OF STATICALLY INDETERMINATE STRUCTURES

By *J. I. Parcel*, Sverdrup and Parcel, Inc., and *R. B. B. Moorman*, Syracuse University. The first half of this book is devoted to a complete presentation of the basic theory of deflections and statically indeterminate structures. Its treatment of the various methods of attack is fully supplemented by numerical examples. The remainder of the study offers practical coverage of the problems facing structural engineers. Includes an important new method of moment distribution in which sidesway takes place automatically. ***1955. 571 pages. $9.50.***

SERVOMECHANISMS AND REGULATING SYSTEM DESIGN

Volume II

By *Harold Chestnut* and *Robert W. Mayer*, both of the General Electric Company. Devoted to both the analytical and practical aspects of servomechanism design. States the problems to be met in design of regulators and feedback control systems and develops methods for their solution. Presents amplifier design factors to minimize gain changes, drift, and changes in tubes. Stresses linearization techniques and non-linear operation for large input signals and deliberate parameter changes. One of a series written in the interest of the advanced course in engineering at the General Electric Company. ***1955. Approx. 385 pages. Prob. $6.50.***

MAGNETIC CONTROL OF INDUSTRIAL MOTORS

Second Edition

By *Gerhart W. Heumann*, General Electric Company. Discusses the external performance characteristics of all types of industrial motors, as well as the components and devices available to the designer. Stresses the theoretical background underlying recognized National Standards and Safety Codes. New material has been included on adjustable voltage and regulating systems. Conventional rheostatic controllers and adjustable voltage equipment is analyzed. One of a series written in the interest of the General Electric Advanced Engineering Program. ***1954. 714 pages. $9.50.***

Send for on-approval copies.

JOHN WILEY & SONS, Inc., 440-4th Ave., New York 16, N.Y.

WILEY — BOOKS

BASIC MATHEMATICS FOR SCIENCE AND ENGINEERING

By *P. G. Andres*, Illinois Institute of Technology; *Hugh J. Miser*, United States Air Force, and *H. Reingold*, Illinois Institute of Technology. Assembles in one volume those topics of elementary mathematics which are basic in engineering theory and practice. Uses terminology and notations commonly found in engineering and science. Emphasis is on numerical calculations, and many realistic problems from engineering, physics, chemistry, etc. are included. The use of the slide rule is discussed early and frequently mentioned thereafter. Final chapters on calculus provide essentials for use in more advanced courses. ***1955.*** *Approx. 746 pages.* *Prob.* ***$6.00.***

INDUSTRIAL PURCHASING

Buying for Industry and Budgetary Institutions

By *J. H. Westing* and *I. V. Fine*, both of the University of Wisconsin; and Members of the Milwaukee Association of Purchasing Agents. A contemporary work on industrial purchasing that covers not only the fundamental principles and policies, but also the broad details of current practice. Divided into five fact-filled sections, the work covers the range of activities and products which concern the purchasing agent and reviews the basic industrial products with which he deals. In addition, it serves as a useful reference on standards and the bases for purchasing policies and procedures. ***1955.*** *Approx. 418 pages.* *Prob.* ***$6.00.***

AGRICULTURAL PROCESS ENGINEERING

By *S. M. Henderson*, University of California, Davis, and *R L. Perry*, University of California, L. A. It treats the engineering viewpoint in its relation to agricultural processing. Includes a wealth of material on fluid-flow measurements and fluid flow through porous media, cleaning and sorting, materials handling, drying, refrigeration, etc. A volume in the Ferguson Foundation Agricultural Engineering Series. ***1955.*** *402 pages.* ***$8.50.***

Send for on-approval copies.

JOHN WILEY & SONS, Inc., 440-4th Ave., New York 16, N.Y.

WILEY — BOOKS

MATERIALS OF CONSTRUCTION, Sixth Edition

By the late *A. P. Mills* and the late *H. W. Hayward;* rewritten and edited by *L. F. Rader*, University of Wisconsin. Fundamentals are carefully treated in the early portion of the text. Individual materials of construction are described in detail, giving a clear understanding of their manufacture, properties, methods of testing, and applications. A great amount of new material is presented, including new information on the service requirements of metals. ***1955.*** *Approx.* ***632*** *pages. Prob.* ***$7.50.***

SOIL AND WATER CONSERVATION ENGINEERING

By *R. K. Frevert* and *G. O. Schwab*, both of Iowa State College; *T. W. Edminster*, U. S. Dept. of Agriculture, and *K. K. Barnes*, Iowa State College. Integrates all known conservation practices and eliminates the need for multiple references. Includes subject matter on the five engineering phases of soil and water conservation. A volume in the Ferguson Foundation Agricultural Engineering Series. ***1955.*** *Approx.* ***508*** *pages. Prob.* ***$8.00.***

INDUSTRIAL MANAGEMENT, Fifth Edition

By *William R. Spriegel*, University of Texas. Written from the viewpoint of the mutuality of interest among customers, owners, and workers, this new edition, based on the original work of Richard H. Lansburgh, stresses the scientific approach to the entire business process. Over 100 new illustrations have been added, and a new chapter on job evaluation has been included. ***1955.*** ***628*** *pages.* ***$6.75.***

PRINCIPLES OF ELECTRIC UTILITY ENGINEERING

By *Charles A. Powel*, The Massachusetts Institute of Technology. A concise review of the business and technical problems facing the electric utility engineer. Covers such subjects as steam-generation stations, transmission equipment, power-system fault control, and others. Co-published with The Technology Press, M.I.T. ***1955.*** *Approx. 256 pages. Prob.* ***$5.00.***

Send for on-approval copies.

JOHN WILEY & SONS, Inc., 440-4th Ave., New York 16, N.Y.

Do You Know—

► The *Annual Meeting* is at Penn State June 20–24, 1955.

► The office of the Society has now been moved from Evanston to Urbana, Illinois and is functioning with an entirely new staff. The office secretary is Mrs. Naomi Garman, formerly employed in the Department of Theoretical and Applied Mechanics; the membership secretary is Mrs. Louise Chambliss who has had considerable business experience; and the typist is Mrs. Dorothy Sams. Both Mrs. Garman and Mrs. Chambliss were able to spend at least a week in Evanston becoming familiar with their duties under the capable direction of Miss Marion Strohm.

Professor C. E. Watson of Northwestern University is continuing as editor of the *Journal* for several months more. All correspondence pertaining to the *Journal* should continue to be sent to Professor Watson at Northwestern Technological Institute. All other correspondence should be directed to:

Professor W. Leighton Collins, Secretary
American Society for Engineering Education
University of Illinois
Urbana, Illinois

Apologies are extended to all whose activities may have been slowed down due to the change in Secretary, the moving of the office, and the training of a new staff. The new office is functioning and should be about caught up by the time you are reading this, but we do ask you to bear with us during our learning period.

► Professor A. B. Bronwell, our former Secretary, is now President of Worcester Polytechnic Institute, Worcester, Mass. Congratulations and best wishes are most sincerely extended to "President Art" along with a gracious "thank you" for his years of service as Secretary of ASEE. But you are not out of the fold, President Art, and some ASEE committee will soon require your services.

Thanks are also expressed to Mrs. Kathryn Cranford and Mrs. Marion Osterholt for their services as membership secretary and editorial secretary, respectively.

► There is supposed to be a page in each issue of the *Journal* entitled "Candid Comments." It is intended to serve as a means by which the members of the Society may briefly express their opinions in letter form and be heard by the entire membership. In the past there hasn't been much interest in the page. Is it because we lack good ideas? We don't want gripes only, but there should be a means by which constructive ideas of individuals can be presented to the membership as a whole.

► The Final Report of the Committee on Evaluation of Engineering Education will be presented at Penn State at the General Session on Tuesday, June 21. Three sub-committees have been at work on specific portions of the Interim Report and are about ready to submit their drafts to the entire committee for approval for the Final Report.

The General Electric Company has contributed another $10,000 to the ASEE for this project and the Engineering Foundation an additional $3000. The Society sincerely expresses its appreciation to these two organizations for their

generous financial support and growing interest in engineering education.

► "Communications—Experiment and Experience" is the theme of the English Division Summer School—Thursday, June 23 through Saturday, June 25 at Penn State. The program will be of interest to all interested in communication as a fundamental of education and not only to teachers of English.

► The Humanistic-Social Research Project is making very substantial progress. Field workers have visited a large number of colleges throughout the country and Dr. George Gullette, Director of the project, has made a tour of the country to investigate those schools which have been identified by the field workers as having something of exceptional promise. A preliminary report of this Committee's work will be presented at the Annual Meeting in June and the Final Report will appear a year from June. This should shape up into a major contribution of the Society.

► The dates for the Fourth Summer School for Chemical Engineering Teachers at Penn State are June 27–July 2.

► The open Conference on "Thermodynamics in Engineering Education" jointly sponsored by ASEE and the National Science Foundation will be held at Penn State on June 27–29.

► The National Science Foundation has been cooperating with ASEE and financially supporting a number of closed conferences on particular areas of subject matter pertinent to engineering education. Topics covered to date are Mechanics—Physics at New York University, Thermodynamics at Purdue, and Electricity and Magnetism at Lehigh; the physicists also have had a closed conference of their own. The reports of these conferences will be published in the *Journal* as soon as they become available. Open conferences for discussion of these reports are planned by the pertinent sections for the Penn State Annual Meeting. The results of these conferences, along with the report on Evaluation of Engineering Education, really will give us something to think about and work on.

► Have you submitted your nominations for members of the next Executive Board? The December and January issues of the *Journal* contained nomination blanks for this purpose. In order to make the election of officers of the Society as democratic as possible, members are urged to fill out the form and return it to the Secretary's Office in Urbana, Illinois by April 1, 1955.

► When you order your copy of the *Teaching Aids Manual*, or any other publication of the Society, write to the Society office at Urbana and *send your check with the order.* Enclosing the check will eliminate separate billing and reduce the amount of work in the office. Thanks for your cooperation.

► When you receive your copy of the Preliminary Program for the Annual Meeting three cards will accompany it. One is for registration, one for housing and one for special events. The latter requests the listing of the special luncheons expected to be attended (not a final commitment) and the Ladies' Program. Fill out all three and return them as instructed on the cards.

► The Ninth Annual Report on "Trends in the Employment of College and University Graduates in Business and Industry" by Dr. F. S. Endicott of Northwestern University, reveals that 145 well-known business and industrial concerns contemplate employing 18.8 percent more engineers, chemists, and physicists next year than this past year, and only 2.2 percent more non-engineering graduates.

► The next meeting of the Executive Board will be during the meeting of the Southeastern Section at Knoxville, Tennessee, April 14–16.

W. LEIGHTON COLLINS, *Secretary*

The Pennsylvania State University

College of Engineering and Architecture

Most of the facilities of the College of Engineering and Architecture at the Pennsylvania State University will be open for inspection when the American Society for Engineering Education meets on the campus June 20–24.

The annual meetings also coincide with the Centennial Celebration of the University, which was chartered in 1855 as The Farmers' High School of Pennsylvania.

Established as an agricultural college, Penn State did not offer work in engineering for more than 20 years. With Pennsylvania's growth as a great industrial state, there was demand for work in engineering and a program was proposed, but lack of funds delayed the actual beginning of such training until after 1880.

The acceptance in 1863 of the Morrill Land-Grant Act which provided for the teaching of "such branches of learning as are related to agriculture and the mechanic arts" also focused attention on the need for engineering work. In 1881, a department of mechanical arts was established and later that year the department of civil engineering which proved to be the beginning of the College of Engineering and Architecture, was organized. The first degrees in engineering were conferred in 1884.

School Established

As a part of a general reorganization program in 1896, the School of Engineering was established and in another campus-wide reorganization in 1953, this became the College of Engineering and Architecture.

The College of Engineering and Architecture was the first of the colleges at Penn State to attain major proportions and a recognized rank among the leading institutions of the United States and for many years it enrolled a large majority of the students on the campus.

Today the College has more than 2,500 undergraduates enrolled in the curriculums of Aeronautical Engineering, Applied Arts, Architecture, Architectural Engineering, Civil Engineering, Electrical Engineering, Engineering Science, Industrial Engineering, Mechanical Engineering, and Sanitary Engineering.

In addition to the 2,500 undergraduates in the College of Engineering and Architecture, students are enrolled in Chemical Engineering, a curriculum in the College of Chemistry and Physics; in Agricultural Engineering, administered jointly by the College of Agriculture and the College of Engineering and Architecture; and in Ceramics, Fuel Technology, Metallurgy, Mineral Preparation Engineering, Mining Engineering, and Petroleum and Natural Gas Engineering, all curriculums in the College of Mineral Industries.

More than 3,100 Engineers

Thus, a total of 3,189 students are enrolled in these curriculums, which is nearly one-third of the total undergraduate student body of 10,422 and a higher percentage of the 7,746 undergraduate men students on the campus. More than 200 graduate students also are majoring in one of the engineering fields.

The curriculum in Engineering Science, which is attracting attention among educators in the engineering field, was introduced two years ago to train students who wish to enter the fields of research, development and other cerative aspects of engineering. To qualify for enrollment in this honors curriculum, students must have had an average of 2.00 or higher during their freshman year

and must be specially chosen for the curriculum by the faculty of the College.

Other new progress of the college are the two-year terminal curriculums in Electrical Technology and in Drafting and Design Technology. Taught only at the Penn State centers, these programs are designed to prepare the engineering technician for many routine engineering assignments so he may assume a supporting role and become an important auxiliary in the modern engineering team.

The College also has developed a cooperative program in engineering which enables young men enrolled in certain liberal arts colleges to transfer to the College of Engineering and Architecture at the end of their junior year. This plan, requiring five years of college work in most cases, enables a student to attend a small liberal arts college near his home and gain a liberal arts education as well as a degree in one of several engineering curriculums.

Last year, the George Westinghouse Professorship in Engineering Education was established in the College of Engineering and Architecture as a means to evaluate and improve methods used in engineering education.

STUDY TRANSISTORS—Experiments with a point-contact transistor are conducted in the Transistor Laboratory at The Pennsylvania State University.

Extensive Research

Research, as well as instruction, is an important part of the activities of the College and the research program is centered in the Ordnance Research Laboratory and in the Department of Engineering Research.

The Ordnance Research Laboratory was opened in 1945 when the Harvard Underwater Sound Laboratory was moved to Penn State. Laboratory personnel conduct research and development work in mechanics, hydraulics, electronics, and acoustics with the operations directed toward creating and developing underwater equipment for the Bureau of Ordnance, U. S. Navy.

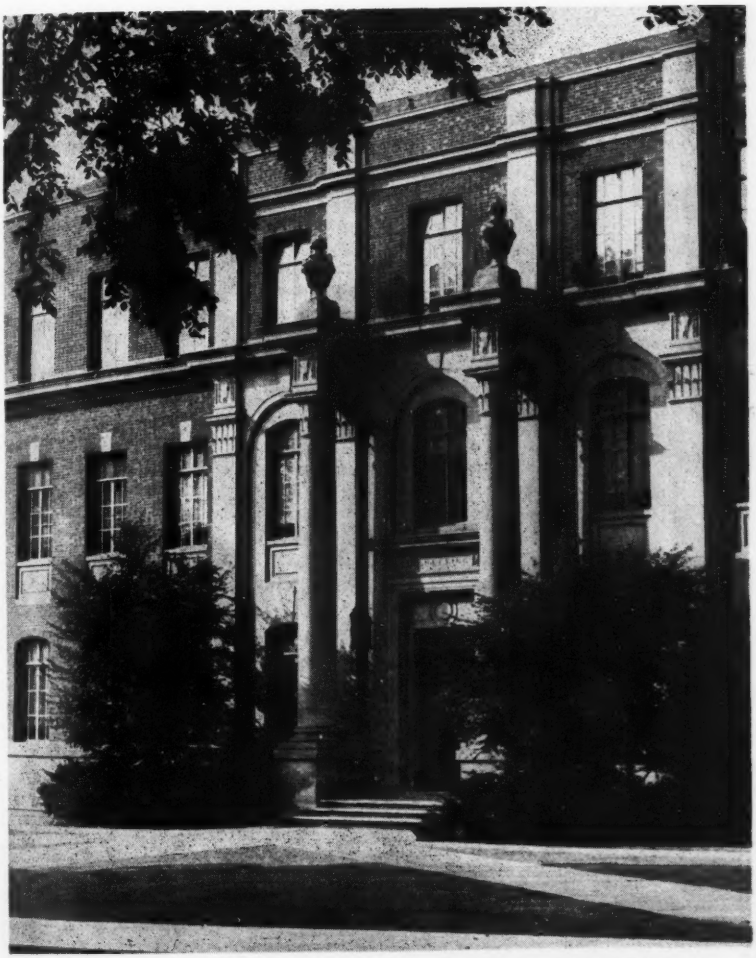
As a part of the Laboratory, the Garfield Thomas Water Tunnel is used for testing designs of propellers, body shapes, and auxiliaries of underwater devices through the use of powered missiles. The tunnel was dedicated in 1949 and is the largest known water tunnel in the world.

The Department of Engineering Research was organized in 1908 as the Engineering Experiment Station.

Since the first research bulletin, concerned with methods for constructing concrete floors, was published in 1910, the Department has published many extensive reports in many technical fields.

Thermal research work has included the investigation of heat and moisture transfer in building and insulating material. Much of this work is conducted in a climatometer built by joint effort with the War Production Board. Here it is possible to simulate all types of weather conditions, including varying humidity conditions and temperatures from—60 degrees to 130 degrees Fahrenheit.

Diesel research work for many years has been an important part of the pro-



MAIN ENGINEERING BUILDING at The Pennsylvania State University.

gram at Penn State and it includes studies of the many phases of operation of Diesel engines with emphasis on fuel injection, combustion, and scavenging. Exhaust energy utilization and the phenomena of finite amplitude pressure waves in engine manifolds and in high pressure lines of pneumatic systems also are under study.

Special problems arising in conjunction with all types of automotive engines, including winterization, all fuel engines, lubrication, and safety devices are studied in the automotive research program.

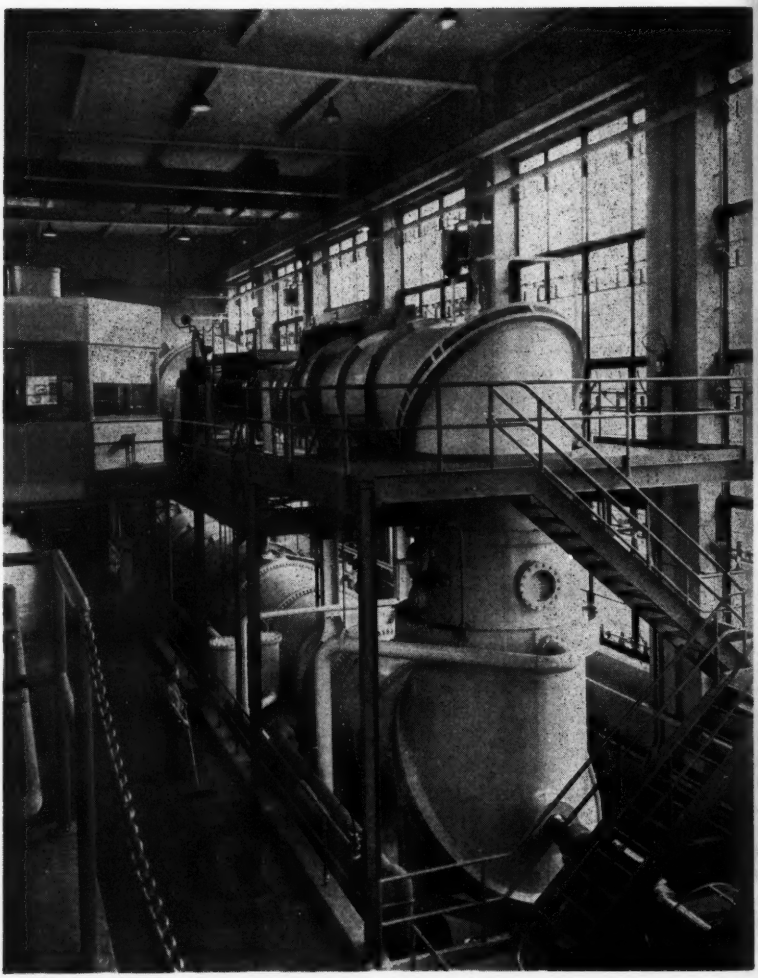
The Ionosphere Research Laboratory has electronic apparatus, field stations, and mobile units with which fundamental

studies of the upper atmosphere and radio wave propagation are studied.

The program in spray research includes fundamental studies on the mechanism of break-up of liquids into aerosols and the influence of various factors on the design and performance of nozzles.

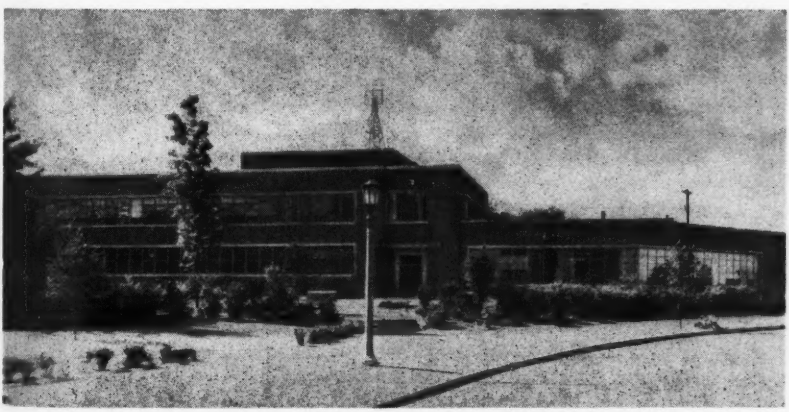
A program in acoustic research is concerned with studies of the vibration characteristics of materials and general problems of noise reduction.

Industries of the Commonwealth, par-



LARGEST WATER TUNNEL—A view of the main tunnel in the Garfield Thomas Water Tunnel building, one of the testing facilities of the Ordnance Research Laboratory at The Pennsylvania State University.

Electrical Engineering Building, The Pennsylvania State University.



ORDNANCE RESEARCH LABORATORY at The Pennsylvania State University provides facilities for important studies for the Navy. Building will be expanded with the addition of a second floor to north and south wings.

ticularly the smaller ones, gain assistance in solving technical problems of an engineering nature through the Industrial Reference Division while a Power Plant Advisory Service furnishes advice on power plant operating and maintenance of the various state institutions.

With the completion of the Nuclear Research Reactor now under construction, Penn State will have facilities for training students in reactor engineering and reactor physics as well as facilities for research in this important field.

The College of Engineering and Architecture also is developing a computer center, which when completed will include an analog computer, a digital computer, and a network analyzer.

Far-flung Facilities and Services

In addition to the instruction and research program on the campus, the College of Engineering and Architecture through the General Extension Services of the University conducts work in many communities of the State.

Class instruction in engineering and technical subjects is available in eleven off-campus centers at several different levels. Courses and refresher programs for graduate engineers, undergraduate subjects for freshmen and sophomores, the two-year technology programs for the training of engineer technicians, and numerous evening school technical institute curriculums are provided.

The program also includes correspondence instruction and informal instruction through lectures, conferences, demonstrations, workshops, and short courses held on and off the campus. An extensive service in management training is offered to the industries of the State.

The College of Engineering and Architecture, because of its rapid growth after work in engineering was started in 1851, was the first college to have its own building. This structure, completed in 1893, was by far the costliest building constructed since Old Main had been

NUCLEAR RESEARCH REACTOR is now under construction at The Pennsylvania State University and will be ready for operation later this year. "Swimming pool" is located in unit at left, shop facilities in unit to right.

COMPRESSION TEST of sand is made on this strength machine in the modern foundry at The Pennsylvania State University.

completed 30 years earlier and it provided facilities for all activities of the new College. In 1918, fire destroyed this building.

Today, the physical facilities of the College include 12 buildings with 280,000 square feet of floor space on the campus, a civil engineering summer camp about 15 miles from the campus, and field stations for the Ordnance Research Laboratory at Black Moshannon Lake near the campus, at Key West, Fla., and at Newport, R. I.

The program in engineering started with one faculty member in 1881 and today the College of Engineering and Architecture has a faculty and staff, including technical and secretarial personnel, of more than 500. Nearly half of this number is affiliated with the Ordnance Research Laboratory.

Since its establishment in 1896 as a school, the College of Engineering and Architecture has been directed by five deans, all of them nationally known in the field of engineering and those of recent years leaders in the American Society for Engineering Education.

Louis E. Reber was appointed the first dean in 1896 and served until 1907 when John Price Jackson was named. In 1915, Robert L. Sackett succeeded Dean Jackson who had resigned in 1914 and in 1937 upon Dean Sackett's retirement Dr. Harry P. Hammond was named dean. He retired in 1951 at which time Dr. Eric A. Walker assumed the deanship of the College.

The following four articles cover some activities of the General Electric Company and Carnegie Institute of Technology in the field of creative engineering—engineering which represents a contribution to the art, as distinguished from the routine application of known skills. Included is a report of the Teaching Methods Seminar, co-sponsored by A.S.E.E. and the General Electric Company. Twenty-eight instructors from as many engineering colleges spent a week in Schenectady as guests of G. E. and actively participated in techniques used at General Electric to foster the creative process of idea synthesis and analysis as applied to engineering problems.—EDITOR.

The Creative Process*

By E. K. VON FANGE
General Electric Company

The objective of this article is to take away much of the mystery and confusion that may exist with respect to the creative process and to present the factors that comprise successful creative engineering.

The Common Denominator

When eulogizing a notable contributor to progress, it is difficult to say whether he had been creative, or merely ingenious, resourceful, brilliant, imaginative, original, an artful contriver, clever, or all of these. For the same contribution, he may also be labeled fanciful, lucky, far-fetched, a good guesser, a daydreamer, or unconventional.

It is the proven or apparent usefulness or quality of the contribution, or some specific condition under which creativity is employed that gives rise to the various shades of meaning offered by the words listed above. And, while these words are useful in semantics, a knowledge of when to use them is unnecessary to understand the creative process. To obtain that understanding, the technique for solving any complex problem will be used, that of dividing the over-all into small portions that can be studied and understood.

A study of these descriptive words indicates that whenever they are used, the persons to whom the words are applied have each done something new or different from what accepted practice would dictate. This holds true whether the men be in research or development, design or product engineering, or in the arts or sciences. It applies equally well for those who are intelligent or moronic, educated or illiterate, married or single. To achieve this, the individual obtained a new combination or application as far as he was concerned. This combination might include an existent device, a mechanism, linkage, or a fundamental law or a just-discovered effect, or a change in attribute such as size, shape, or color.

Creativity, then, is the obtaining of a combination of things or attributes that is new as far as the creator is concerned. As a direct corollary, *any time one does something for the first time, without being shown how, he is, so far as his mental process is concerned, being creative.*

A student, apprentice, or beginner must be creative *if he has not been specifically shown how to accomplish a problem or a task.* For example, initial study of a word problem in any mathematics textbook typically does not reveal the solution or the steps to take to achieve the solution. It is only by careful search of the chapter contents and the process of trial combinations of bits of knowledge that the student arrives at the right combina-

* A revision of a paper presented at the annual meeting of the National Capital Area Section, A.S.E.E., at the Catholic University of America on May 8, 1954.

tion to give the answer. The motivation, though, is through desire to conform, and it ceases, unfortunately, when that has been accomplished.

Because creativity is to place already existing things or attributes into new combinations, it was difficult under the old laws to obtain an unbreakable patent. The competitor merely had to separate the invention into its component parts, find an existing device that contained that component and present this evidence to the court. The court would often rule that, since the individual components were already in existence, the combination of them in the form proposed would be apparent to anyone skilled in the art, and thus, not a valid patent.

By definition, then, all people are or are able to be creative. Their creations, however, can be useful, useless, or even detrimental. For example, pioneers of all ages set out from their homeland with a minimum of equipment, and from the materials of nature created a successful livelihood. The Seabees earned immortal fame by building airstrips and other needs of war under great adversity. Stage productions are often presented on a shoestring budget. Many laboratory experiments are conducted with inadequate equipment. In contrast, individuals are uselessly creative when they worry about imaginary evils, or idly build dream castles in the air, or slowly rationalize themselves into contentment with their past successes or habits.

Creative Expression often Stifled

A child, normally, is quite creative. But the child lacks judgment, and most of his early creative expressions are met with choruses of "don't." Similarly, from grammar school on, emphasis is placed on subjugation to fixed and well-explained text assignments, closely directed laboratory experiments, and well-disciplined study periods. Now, this in itself isn't bad EXCEPT, there is little or no outlet provided for creative expression. As a result, creativity and curiosity dwindle and fall asleep through sheer lack of exercise. It is like building roads and railroads and factories to make use of a wonderful natural harbor, and then becoming so engrossed in this effort that the harbor is forgotten and becomes covered over by drifting sand.

This submergence of creative expression is not due alone to the factors just mentioned. A child who, through physical characteristics inherited by birth, or the child who, by necessity is clothed differently from the remainder of the class or the members of the gang, is a subject of much laughter and derision. After so many object lessons in *conformity* it is rare indeed for creativity not to be stifled.

Eventually, this has the effect of lulling people into the feeling that there is no opportunity for creativity in the solution of their problems and causes them to actually resist changes. (It is necessary to distinguish between this and conformity by choice, which often is desirable in some parts of creative work to efficiently achieve a goal.)

The usual college training also adversely affects creativity. For example, the assignments given in a typical engineering institution might be likened to a foot-bridge swaying across a wide and deep chasm. The problem is the bridge. At the other end of the bridge lies the solution. Strong and sturdy guide rails are formed by the detailed definition, boundary conditions, the applicable formulas or procedures given in the text, etc. As the student goes through his years of education, he is sent across progressively longer bridges, though each is still adequately protected by guard rails, and he has little difficulty. Then, upon graduation, the guard rails are removed and he is told his sheepskin equips him well to start across the bridge. No wonder new engineers may be hesitant and undecided about what to do and how to do it! And no wonder, too, that they learn to use the safely guarded bridges of the conventional in their engineering career and refuse to cross a creative bridge if they see it, simply because it has no guard rails to guide them.

After so many years of doing exercises at the end of a chapter that have only one answer, one approach, and one method, and with all the knowledge required found in the written material immediately preceding, it is not difficult to see why an industry exists today in which any automobile design is all right as long as it keeps the horsepower up front like grandpa's buggy. It must have four wheels, also like grandpa's buggy. It has hinged doors and roll-down windows like the old stagecoaches, even though all of this may not be the most economical or the most practical design. And any refrigerator design is all right as long as it looks like an icebox. Any electric range or gas range is all right as long as it closely resembles the old wood stove. Because of their educational background, many engineers do not even realize that there are many approaches to the solution of any problems for which they may have responsibility, and there are many methods for making each of these approaches do the job required. A recent article said, in effect, that the basic radio circuit has been simplified or perfected to such an extent that no further improvement is to be expected. Someone, some day, will take that as a challenge. He will look for and find a new approach, and a new radio circuit will be created.

Another stifler is that as the standard of living progressively increases, individuals become more self-satisfied with the status quo; and *self-satisfaction or contentment with what one has is the very enemy of creativity.* The individual who first observed, "The dead live in us" summed the situation very nicely. In too many cases progress and growth are impeded because judicial thought processes *depose* instead of *dispose* a creative contribution. And so, even though industry may recognize and create a more efficient automobile or refrigerator or range, customers will not buy if the product is too different.

But perhaps the biggest stifler of useful creativity stems from its definition. It is inherent that the creative "bridge" is initially untested, full of unknown and possible dangers over its entire span. In many cases it is only through a fierce determination to succeed that a creative process can be successful. It is easy to see why, when reading about notable inventors and others active in the creative process, the great elation they felt when the bridge was finally crossed is so vividly recorded. It is the same thrill that exists in any situation where a human sets himself a challenge, and is victorious over that challenge. It is pathetic that so few have enjoyed this thrill. For these creative bridges can be and have been safely crossed time and time again by the strong-willed few who dared. And anyone can safely dare if he will merely practice.

From the factors listed, it should be evident that *a strong desire to create is essential in the useful creative process.* In engineering, this desire in the past has too often come only when competition or other factors have forced the discarding of the old blueprints or techniques. But even though the strong desire exists, and the individual can easily achieve new combinations, a successful result is not assured. The creator must also be capable of achieving understanding in the area in which he wishes to create.

An individual may exhibit creativity no matter what his level of understanding is. However, the usefulness of the ideas generated is strictly a function(neglecting rare chance) of his understanding of the fundamental concepts involved. This is evidenced by the lower quality of the ideas that occur after an initial study or exposure to a problem. Often these first ideas are found to be inapplicable after additional effort is expended.

However, if a study is made to see how an understanding is achieved, one finds that understanding increases as a function of the number of times he is exposed to a situation (such as learning to drive a car), or the number of times he is called upon to analyze or generalize or use a concept. For example, each time a new theorem is presented in a mathe-

matics course, the student achieves understanding by successively solving more difficult and different problems employing the theorem in their solution. His understanding is increased still more if he takes what he has learned through solving the specific problems and generalizes to find other areas from his background where the application of the theorem would be useful.

In the two previous paragraphs two interrelated statements have been made. First, the usefulness of a new combination is a function of the understanding that produced it; second, understanding increases with the number of times the material to be understood is analyzed, generalized, or otherwise applied or employed. In a typical engineering problem, then, the more possible approaches and methods that can be obtained for evaluation, the better will be the resultant understanding of how best to solve the problem. And as this understanding increases, the additional idea combinations obtained will better accomplish the solution.

The best ideas are often ridiculously simple once they have been thought of, but the embryonic solutions that led to this simple result were really ridiculous, when one looks back and compares. However, they were essential steps in achieving an understanding of how to best solve the problem. It becomes obvious, then, why people who train throughout all their educational experience in the one problem-one solution philosophy experience difficulty in achieving this understanding. Typically, the first method that occurs to them is the only one as far as they are concerned. Unfortunately, it is seldom the best.

Development Factors

From the foregoing, it would appear that heredity affects successful creation in two ways. First, intelligence (which may be defined as the measure of incompleteness with which the whole can be grasped) is the limiting factor in determining the complexity of the situation in which the individual can eventually achieve understanding and create a solution. Second, man's other aptitudes indicate the vocation where he can make the maximum contribution. Training, then, has the objective of overcoming the effects of previous environment so that each man will be as usefully and efficiently productive as his intelligence will permit.

Making the Decision

If a person desires to develop his creative ability, this is a first and essential step. A person may wish to learn how to play the piano. He may go so far as to actually buy or rent a piano. He may send off for self-teaching lessons, and he may doodle with the keys once or twice; but until he actually makes the decision to learn to play; until he actually schedules regular practice time to help him accomplish his objective, he has never really made the decision to learn. And so it is with the creative process. Until one regularly schedules practice and study towards improving his creative productivity, he is rendering nothing but lip-service and the decision to create is lacking. This decision must be made before a person is prepared to meet the challenge of the rocky unknowns of an untried path inherent in the creative process.

Many are attracted by the thought of developing their facility in creative expression, but rapidly lose interest when obstacles are encountered in the reduction of their ideas to usable practicality, especially if it requires learning new knowledge through study or extensive experimentation, or if an understanding requires unfamiliar mathematics to be used. Thus, the willingness to accept the challenge of useful and repetitive creation involves the possession of a high degree of initiative and perseverance. Fortunately, the thrilling sensation obtained from the hunt and at the successful conclusion of a creative endeavor seems to always equal or exceed the effort that was required.

Focus

In an engineering activity it often happens that, even though a person has the strong desire to create, he flits from topic to topic just looking, and because of this he may never get an idea, for he is depending upon an instantaneous "flash of genius" which is a rare occurrence. If he were to settle quickly on just one of those areas, and give it the benefit of deliberate thought, time after time a worthy idea contribution would result.

It is basic to repetitive and successful creation that a person learn to establish quickly a focal point on which to direct his efforts.

Existing Knowledge

Many individuals are able to graduate successfully from school having used only the knowledge found in their textbooks. They seemingly continue unaware of the great reservoir available in libraries, government publications, laboratories, and through regular reading of trade journals. Not only does this deny them many good ideas, but it also leads to needless duplication of effort.

It is also necessary to learn to separate factual knowledge from opinion and assumption. This involves learning not only an equation or formula, for example, but also the assumptions that allow the concept to be expressed so simply. It also requires that he get his knowledge from the best sources. For instance, if another engineer tells him that his idea or design is good, but is already patented, will cost too much, or will never pass Underwriters' tests, he does not accept this as final, but goes to the patent attorney, or manufacturing planner, or Underwriters for the facts. If he is told "We've already tried that and it won't work," he investigates to insure that all conditions were identical. Most of the fundamental advances in progress would not have been made if their creators had listened to the *opinions* offered them.

An engineering project, naturally, cannot be a continuous search for newer and better ways. Unfortunately, after individuals become proficient in creative endeavor, it can become very difficult for them to stop looking and start building. Each better way found improves their understanding and becomes bait to lure them into a little more searching for an even better method. This emphasizes the importance of sound planning to determine when the search must stop in order for construction, testing, etc., to be complete by the due date.

There are two extremes in creative activity. One is to take the first method that gives technical excellence, i.e., a design that will perform satisfactorily the required length of time in the environment imposed. The other extreme is to never stop searching for an even better way. In between lies the road to leadership.

If man were content with his present status, he would have no need for a creative process. He would perform routines, chores, or exercises, and he would exist on what his fathers had handed down to him. It is only when he is not content; when he wants such things as a greater understanding of nature, a greater security against disease, accidents, the elements, and his real or imagined enemies, a greater income or prestige, an improved way of teaching or otherwise serving or helping others that he has this need. It can readily be appreciated that man's desire is quite dependent upon his particular environment. Certain societies, past and present, were so content that no desire existed and no change in culture or techniques were observable for hundreds of years. In fact, a study of history finds the phrase: "the rise and fall of—" used repeatedly. Initially, there is a great awakening, a renaissance, followed by a period of great prosperity and influence. Eventually, a stage of blissful contentment takes hold, an ever-increasing corruption often becomes evident, and the once powerful becomes senile. And this same pattern is all too evident within those segments of industry where precautions against it have

not been taken. Product leaders, blissfully content with their design, wake suddenly to find themselves bankrupt or in a minor competitive position. The same pattern can also be found in individuals who do not take steps to prevent it. They learn and absorb rapidly through schooling and their initial years at a job, eventually becoming content with their level of development and the magnitude of their contribution, and become a stagnant liability rather than an aggressive asset. The Biblical passage, "To him that thinketh he standeth, take heed lest he fall" is quite apropos.

Creative effort, then, arises through man's desire to build a better future, and he learns best what to "build" through a study of the past. Many errors in judgment (and thus misdirected efforts) have been made by not properly investigating the past (or present) to obtain direction. Thus, time for thorough investigation of needs and ways of satisfying them becomes an all-important factor in giving sound basis to judgment in the creative process.

The Creative Process

Man decides to improve

1) Investigates to determine which of many directions will provide the most value for time and money expended.

2) Defines selected direction to make it distinct by specifying the limits or boundaries.

3) Searches in an endeavor to find or ascertain all possible methods of solution.

4) Evaluates each of these to obtain understanding of how best to solve.

5) Executes by completing or performing the solution using the selected method.

6) Interprets by explaining or translating the results to convince others.

The progress of civilization at any period from the time man first existed on the earth is a function of (1) the existing quantity of separate thoughts and things; (2) the intercommunication that was possible between different tribes, peoples, and nations; (3) the permissive atmosphere that existed as his environment. Look, then, at the tremendous opportunities for creative expression today. Each new idea becomes in itself an additional building block to be combined with any of the already existent blocks. Thus, creativity is not a degenerative thing; the patent office need never be closed because everything has been invented. Rather, creativity is a regenerative process; each new contribution permits a whole series of additional combinations or creations.

Sections and Branches

The annual meeting of the **North Midwest Section** of the ASEE was held at Michigan College of M. & T. on October 8-9, 1954. The YET program was brought up for discussion and it was pointed out that such a program could be of great help to the younger teachers.

An invitation was extended to the Section to hold its 1955 meeting at the South Dakota State College early in October, 1955. A motion was made and carried to accept this invitation.

The nominating committee presented the following slate of officers: *Chairman*, L. L. Amidon; *Vice Chairman*, J. W. Howe; *Secretary-Treasurer*, J. O. Storry. It was moved and supported that the secretary be instructed to cast a unanimous ballot for the slate of candidates presented by the nominating committee. Motion carried.

The Creative Engineering Program

By C. FRANK HIX, JR.

General Electric Company

An engineer with creative ability has always been much sought after in industry. Products now found in the market would not be there but for the efforts of men with this ability. Technical knowledge is expanding rapidly. This only seems to increase the need for creative talent in present engineering organizations. It is needed to make the improvements on existing products, to create tomorrow's products, and to develop new manufacturing equipment.

Even though management has ever been on the lookout for men possessing this ability, their discovery in the past has been for the most part happenstance. It has usually been necessary for the creative spark to assert itself under conditions which did not encourage creative work or give opportunity for its practice. Men could be typed according to interest and ability, i.e. sales, research, design, or manufacture. But seldom was the responsibility for a major project requiring broad creative ability and practical design sense ever entrusted to him. Under these circumstances, only exceptional men gained recognition for creative genius, resulting in the intuitive abilities of countless engineers being lost to both industry and society.

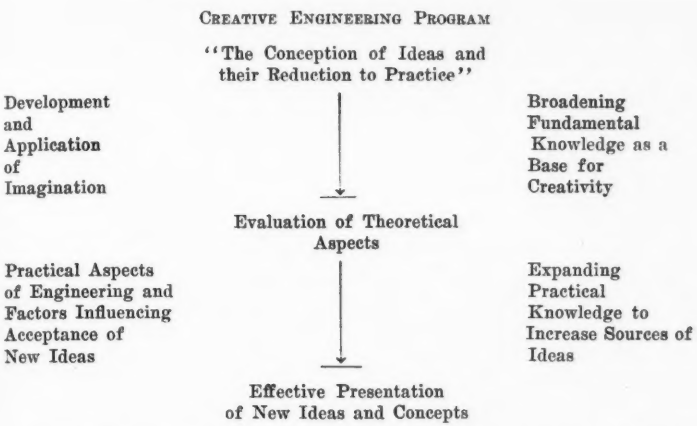
The Creative Engineering Program of the General Electric Company offers the opportunity to young engineers first to develop and then apply their latent creativeness in a permissive atmosphere. The development of this creative ability has at its core the conception of ideas. But the Program training does not stop there, and perhaps a little story will best tell why.

A teacher was well known for his wisdom, and one of his students decided to test him. The student caught a small bird and went to the teacher's home. "I will ask him if the bird in my hand is alive," he thought. "If he says it is, I will crush it; if he says it is dead, I will release it." But when he asked his teacher this question, the wise man said, "The choice is yours."

At each step in the development of an idea, it can die as easily as the bird in the student's hand chiefly because the immediate possessor of it or a person coming into contact with it does not recognize its importance or his influence over it. It is on this point that an industry can become stronger or can stagnate through the value of the one idea that is given or denied. Careers advance or become static to the degree that a person has the ability to recognize progressive thinking and to see that it is applied most effectively. In other words, ideas and sound thinking can be stifled or poorly utilized, or they can be weighed carefully and strengthened to further technical knowledge and human progress.

This, then, is the purpose of the Creative Engineering Program: To increase engineers' ability to gain ideas, to strengthen them on the basis of sound thinking, to utilize them fully, and ultimately to get acceptance for them.

Creative engineering can be stated as the engineering that is performed on a given assignment which represents a contribution to the art as separate from the routine application of known skills. It is not important whether the job is one of development, design, manufacture, or sales. For if an engineer can consistently bring about a new and different practical


CREATIVE ENGINEERING PROGRAM
"The Conception of Ideas and their Reduction to Practice"
Development and Application of Imagination
Broadening Fundamental Knowledge as a Base for Creativity
Evaluation of Theoretical Aspects
Practical Aspects of Engineering and Factors Influencing Acceptance of New Ideas
Expanding Practical Knowledge to Increase Sources of Ideas
Effective Presentation of New Ideas and Concepts

Shown here are the curriculum goals of the Creative Engineering Program

solution to a problem, he can be termed creative. A creative design costs less and performs better in the ways the user values most.

There are four important aspects to developing creative talent. The relationship between three of them can be easily visualized. The use of one's imagination is most important in getting ideas. The base of the reservoir from which one draws his ideas, however, has as its length the familiarity with theoretical fundamentals of engineering, and its width the practical applications of these fundamentals. The depth of the reservoir is the understanding of the significance of this knowledge. Ideas can be taken from this reservoir, sometimes at will, often only after conscientious study, and once or twice in a lifetime as the "flash of genius."

The fourth aspect involved is the manner or approach one takes toward solving a problem and applying the fruits of his creative effort. This approach can be refined to the following four steps: (1) Definition of the Problem; (2) Search for Methods of Solution; (3) Evaluation and Selection of a Method; (4) Details of Solution Evaluation.

A curriculum has been established which encompasses the above four points. It has proved itself in the accomplishing of the goals of the Program.

The C.E.P. curriculum concentrates on the conception of new ideas to solve engineering problems. It does this by the development and application of one's imagination and by increasing fundamental engineering knowledge. Rotating engineering assignments and the homework problems call for the practice and refinement of the material presented and the evaluation of the theoretical aspects. Also, the curriculum bridges the gap from idea to practical use.

Inherent in the Program is a plausible and integrated engineering philosophy that is both instructive and stimulating to the young and inexperienced engineer. The level of technical (or analytical) ability expected of the engineer at the beginning is equivalent to a college degree in general engineering. The wide diversity of college specialties found among the graduates precludes any other assumption. Therefore, by accepting a set of criteria for a creative engineer, i.e. a creative approach to a problem, an active and inquisitive mind, a broad background of information and fundamental knowledge, ability to present ideas and

problem solutions effectively, the initiative to get a job done, and the ability to get along with people, a curriculum has been established to develop and bring out the latent ability of the engineer in each of these areas.

The training consists of three interrelated phases: rotating assignments, class work, and homework.

Rotating Assignment

The training provided during normal working hours consists of a series of organized assignments under the direction of senior engineers acknowledged to possess creative ability. These engineers take special care to develop imagination and skills through discussion and personal example. In so far as possible, the young engineer is given complete responsibility for the development or design of a device so that he may gain early the confidence essential to a productive career.

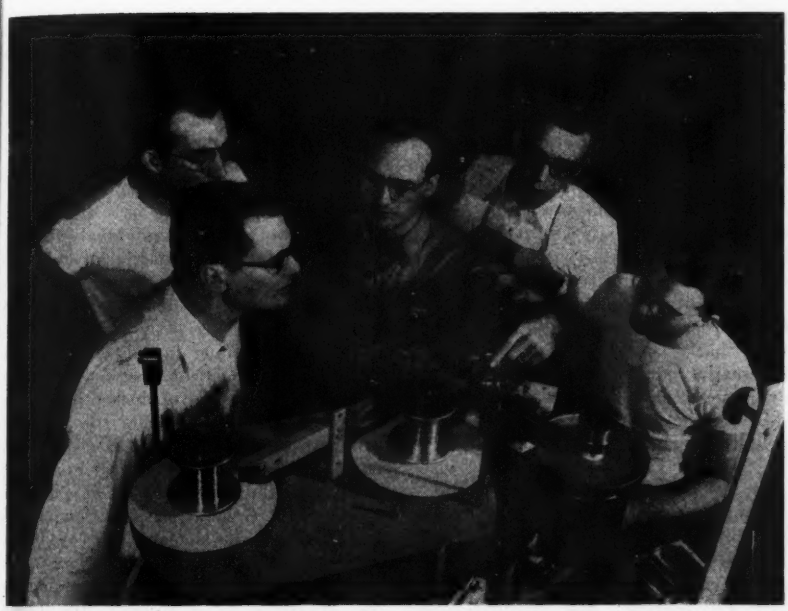
In the course of a year, each young engineer works in four assignment areas.

Class Work

The classes are held once a week, four hours per class, on Company time. The class usually consists of guest lectures and student discussions. The classes are supervised by recent graduates of the Program. The class supervisors organize the class work and arrange for lecturers and class leaders. These supervisors recognize the problems of the young engineer and through counseling help him derive the most benefit from the training.

The classroom sessions are the nucleus for the technical and creative growth of the members of the Program. Their abilities are developed through practice. Much class time is devoted to the practice and discussion of the known creative techniques. The technical material in mechanical and electrical subjects is given

John Bayles, B.S.E., Tulane, presents new radar antenna tilt drive principle to product department engineers



Preston Hammond, B.S.M.E., Bradley, explains operation of automatic small wire spool changer to class members. (Both devices shown here were developed by 3-man project teams as part of their class effort)

to increase the general understanding of fundamental knowledge. The presentation of a creative approach to new and different engineering problems is molded into a philosophy of engineering.

No idea and no problem solution, no matter how good, is worth a penny until it has been sold to someone. Written and oral presentation, including visual representation of one's thoughts is included all through the class curriculum.

Homework

The organization of one's resources to focus on a problem is the first step tackled in homework problems. Eighty percent of all homework problems are design problems of current interest to the Company's engineering departments. These new and live problems stimulate creative thinking and the "nonhabitual" approach. Thus each young engineer develops a creative technique best suited for himself. Solutions to these problems are often of use to the product departments concerned.

The initial contact with these problems is through a one week study with the results presented in an engineering report. Technically, there is no difference in homework problems and those tackled by operating departments other than the magnitude of effort involved, and the extent to which results are carried toward a salable product. By the end of the C.E.P., several larger projects have been tackled, this time in groups of three or four men. Team work is necessary to solve these problems. The last project tackled finds results carried to a point where many manufacturing details are incorporated. This gives the trainee a practical concept of all of the elements that contribute cost to his products.

This, of course, opens the door for creatively reducing product costs.

Selection Process

The applicants for the Creative Engineering Program come from those young engineers taking the Advanced Technical Course. This latter course is primarily an engineering problem course. After one year of participation in the Advanced Technical Course, starting in September, men are selected on the basis of interest in and ability to do creative engineering. This process allows those candidates whose background shows little evidence of creative ability to get special trial assignments in the conception of new ideas and the design of new testing equipment to spark unsuspected talent.

Opportunities for Graduates

Upon completion of this Program, opportunities are opened to the graduates in three major areas. These are: Advance or Development Engineering; Design Engineering; and Manufacturing Engineering. Again in the transfer to an operating department, as in selection for the Program, each man is considered as to his interests and abilities for each opening in the Company that exists at the time of graduation. The Program, while still young, has seen many of its graduates advance into responsible positions and contribute to many of the Company's creative achievements.

The Results Achieved

In the 16 years the Program has been operated, a total of 347 men have graduated from it. The graduates have been of two types. First, a small proportion have possessed a very high degree of inventiveness and have been interested only in the developmental phases of engineering. They thrive on new problems but have little interest in carrying through to a finished product once the method of accomplishing the result is known and proved. Secondly, a majority of the graduates have followed the objectives of the Program more closely. They are design engineers who apply ingenuity at the proper stages of the design problems but who get immense satisfaction from carrying the work through to a finished product ready for delivery to the customer. In industry the number of opportunities are more prevalent for this latter type.

In both groups there have been many examples of broad individual achievement considering the comparatively short experience of the graduates. Most of them have several patent dockets by the time their rotating assignments are finished and continue in this direction on their more permanent assignments which follow. The number of dockets which are carried through to patents for Program graduates indicates several times the patent productivity of non-program men. An indication of the value of the Program to the General Electric Company is reflected by the demand for graduates which has consistently run many times the number of men available. A number of graduates have received the Coffin Award—the Company's highest award in recognition of outstanding engineering contributions.

The Program has definitely proved itself. Naturally, like most training programs, it has been possible only to provide an introduction to the field of creative engineering. Each graduate has received encouragement to do this type of work, has gained practice in it, and has in some measure "glimpsed the horizon." After graduation, except for departmental supervision and stimulation, he is left on his own to continue his study and development as he rises in professional stature. It is felt that his full potentialities have not yet been realized because of the period of years required for full expression of creative talent. His ultimate worth depends on the further progress he makes towards understanding his own abilities and in receiving continued encouragement to develop these abilities throughout his professional career.

Report of the 1954 American Society for Engineering Education-General Electric Teaching Methods Seminar, August 30 through Sept. 4, 1954

By R. H. BUESCHER

General Electric Company

Almost everywhere you go, you will find the practicing engineer aware of the differences between the college campus and the industrial world. He realizes only too well how his day-to-day learning differs from that absorbed in the engineering schools. The student works to solve the theoretical problems of next week's quiz. The engineer works to solve the practical problems of industry.

A unique approach to the problem of bridging the gap between college and industry is the program of industrial cooperation with colleges—not only with schools in a given area, but through direct nationwide contact with educators. By sharing industrial and institutional teaching techniques and philosophy perhaps we can ultimately close the gap.

This is to report on the latest ASEE–GE endeavor in approaching this problem. The third consecutive teaching methods seminar was presented in Schenectady from August 30 through September 4. This seminar, like the two preceding seminars, was sponsored jointly by the Educational Methods Division of the American Society for Engineering Education and the General Electric Company. Its purpose was to acquaint college instructors with "The Creative Engineering Program at General Electric and to have them actively participate in the creative process of idea synthesis and analysis as applied to engineering problems.

Twenty-eight instructors of electrical, mechanical, chemical, and industrial engineering attended the 1954 seminar. These candidates were selected on the basis of geographical and curricular distributions and the nominations of the various deans of the accredited colleges.

From previous seminars, the objectives of the 1954 seminar had evolved as follows:

1) To present some of the teaching techniques which General Electric has used to advantage in its Advanced Technical Programs.

2) To show one method of application of these teaching techniques to undergraduate collegiate instruction.

3) To provide a medium of free interchange of various techniques presented by the seminar members, in an atmosphere conducive to learning.

Perhaps these objectives and the way in which the seminar tried to meet them can best be described by presenting a sketchy chronological diary of the activities throughout the week. Housing and living accommodations were arranged in one of the fraternity houses on the campus of Union College, thereby providing in a measure some of the informal atmosphere desired to meet the third objective.

The first morning of the seminar contained the only formal portion of the entire week, and this was for only one hour. Words of welcome and explanation of the seminar schedule were presented by Dean B. R. Teare, Vice President of the A.S.E.E., and Messrs. M. M. Boring, A. M. Anderson, and R. H. Buescher, of General Electric. At the conclusions of these presentations, the free invitation to informality was expressed, with later meetings being discussions rather than lectures.

Learning by Doing

One of the techniques which General Electric hoped to present was its use of the philosophy of "learning by doing." Perhaps the best way to teach this technique is to apply the method itself. This the seminar staff decided to do. On Monday morning, the instructors in attendance were asked to work problems given on an entrance examination. These short problems were designed to (a) illustrate the type of quiz used in General Electric's Advanced Technical Programs, and (b) show the need for real understanding rather than superficiality in the solution of engineering problems.

That same afternoon, the philosophy of "learning by doing" was continued in the presentation of another engineering problem. Dr. D. W. Ver Planck, Head of the Department of Mechanical Engineering, Carnegie Institute of Technology, asked the group to consider the following problem: "A given inertia load is to be accelerated at its maximum rate with a given motor. There is the possibility that a simple two-gear system may be employed. Investigate its desirability and in 8 hours report your findings."

This problem was designed to show a way in which "learning by doing" could be used in undergraduate collegiate classes—in this case, Dr. Ver Planck's Engineering Analysis Courses which are presented at Carnegie Institute of Technology in Pittsburgh. The problem, typical of real engineering problems, was "ill-defined" and "open-ended." No qualifying assumptions were forced upon the "student" and no particular results were specified. As work progressed, more facets of the analysis became apparent, important, and eventually explored.

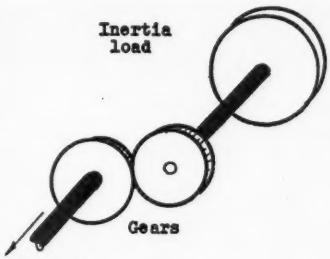
As a follow-up, Dr. Ver Planck reviewed the work of the instructors and presented the solution of the problem in a similar fashion as he would do to his own students at Carnegie Tech.

The next day, Mr. E. K. Von Fange of General Electric's Engineering Education staff presented a typical problem used in GE's Advanced Technical Programs. The problem was to consider, with a view toward improvement, a current model of a radar antenna tilt drive, which was obviously bulky, complicated, and costly. Again the problem was typical of industrial problems in that it was not very well defined and provided the opportunity for a "no holds barred" kind of approach. This kind of problem, although common in industrial practice, was a rather new situation to some of the seminar participants; however, the group soon began to develop many ideas for improvements.

After a few hours of individual and small group study, Mr. Von Fange called the group together to discuss the progress thus far. Six ideas were forthcoming on various ways in which a conical radar beam could be generated. It was interesting to note that as each of these ideas was brought forth, additional people in the group discussed them, evaluated them, and in a measure judged their worth. At this time, Mr. Von Fange introduced another technique used often in General Electric's Advanced Technical Programs—the "brainstorm" session.

Brainstorm Session

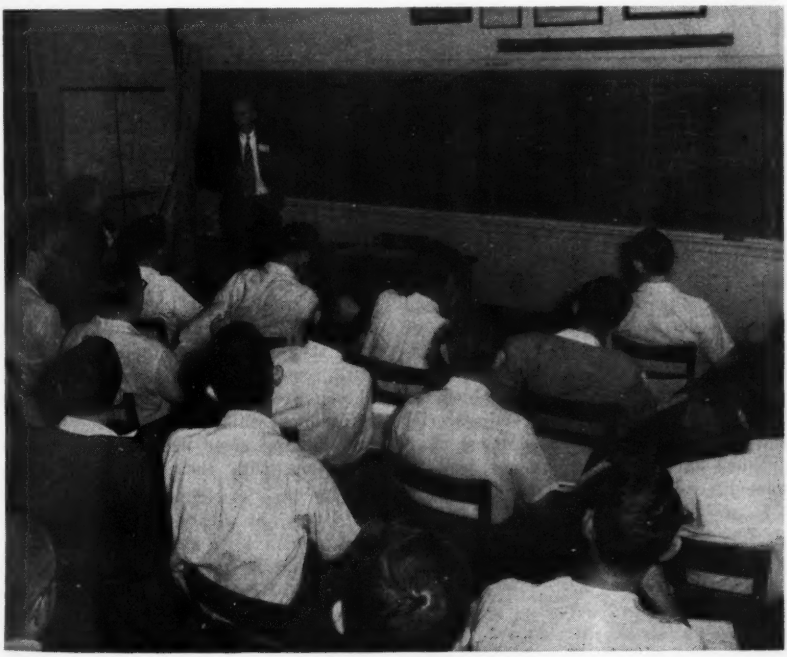
The brainstorm session was described as a discussion in which ideas are brought forth but no attempt made to judge them or to consider them in any fashion, but rather to use them to stimulate further ideas. As two ideas are brought forth,



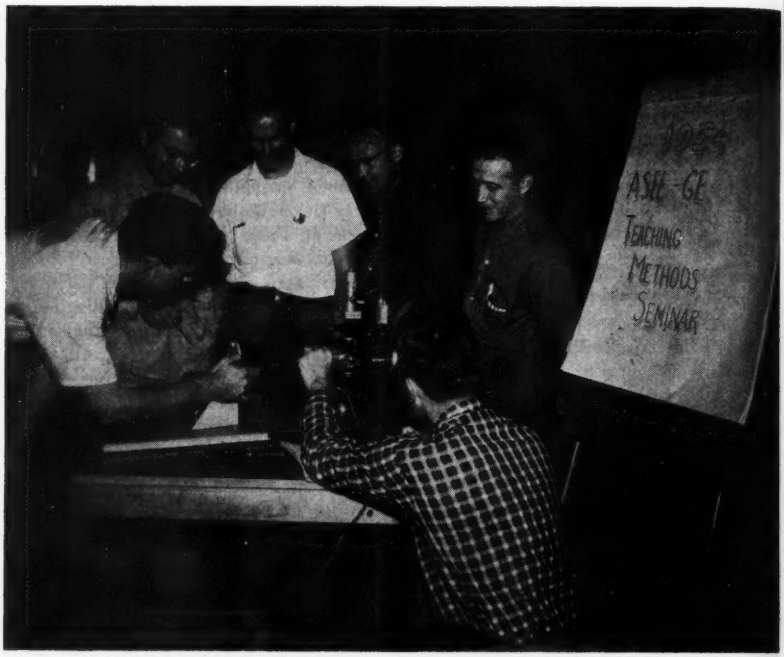
The First Seminar Problem presented by D. W. VerPlanck

perhaps a third will result from the combination, and additional ideas result from the additional combinations. This technique, when applied by the seminar participants, evolved 38 additional ideas in the space of 20 minutes, evidencing the potency of the brainstorm technique.

During the following 15 hours devoted to solving this engineering problem, a good deal of emphasis was placed upon definition of the problem, search for methods, evaluation of the methods, and carry-through on solving the problem. Each of these steps is important in a problem-solving process. It is felt that one or more of these steps is often only superficially considered in collegiate instruction. It was the hope of the seminar staff that the importance of all of the steps in the problem-solving process would be considered and evaluated by the seminar participants. Many of the solutions which evolved from the seminar group working on the problem were



D. W. VerPlanck (Head, Dept. of ME, Carnegie Institute of Technology) discussing the first Seminar problem with the participants



E. K. Von Fange (General Electric Co.) discussing the second Seminar problem with a group of the participants

crystallized enough to merit continued consideration had the seminar been longer.

During the seminar week, additional time was devoted to group discussions of educational techniques brought by various seminar participants. Among those considered was the general problem of instructor education, use of laboratories and projects in the presentation of a problem-solving philosophy, as well as some time devoted to plant tours and a visit to historical points of interest in the area.

The 1954 Teaching Methods Seminar participants worked hard, with a full schedule, but A.S.E.E. and G.E. hope that they returned to their schools filled with continued enthusiasm for their chosen profession, armed with some new techniques which might prove helpful, and holding some memories of new associations with their colleagues in industry.

Engineering Analysis as Training in Ingenuity

By D. W. VER PLANCK

Head, Department of Mechanical Engineering, Carnegie Institute of Technology

The process of inventing or creating a new product or process often is considered to be the antithesis of analysis, and, indeed, this is true if a well defined situation is being treated by means of a well known procedure with which the analyst is thoroughly familiar. However, if one thinks of analysis more broadly as including the whole process by which an engineer copes with his problems and finally reaches decisions, then it is found that analysis requires the exercise of ingenuity and inventiveness in much the same way as does the creation of something new. Whether the engineer is analyzing a complicated situation or is endeavoring to find a new way of doing something he must bring to bear all of the appropriate knowledge, methods, and means which he has at his disposal or can acquire for the purpose. Helping students to learn to do this is the function of courses which we call Engineering Analysis.* In what follows I shall try to show how such a course can help students exercise and develop ingenuity and so help them toward a capacity for creativeness, which certainly depends heavily on ingenuity, if indeed, it is not the same thing.

Our Engineering Analysis courses have as their object training in the art of solving engineering problems, particularly those which are susceptible to some sort of analytic rather than experimental attack. The subject matter of the problems may be anything related to the student's professional field. For example, problems for mechanical engineering seniors may be concerned with such diverse subjects as heat transfer, stress analysis, vibrations, economics, heat pumps, and electro-mechanical servo systems. The course confronts the student with problems completely new to him—ones which he is unlikely to find worked in reference books or ever to have met before—and is devoted to helping the student develop a systematic and professional style for attacking such new and unfamiliar problems. He is taught to ferret out the real problem from a confused situation, to plan how to use what he knows to solve it, to check his work in every reasonable way as he goes along, and finally to draw sound conclusions from what he finds. Each problem requires from six to eight hours of outside work. Class periods are devoted mainly to discussing problems already worked by the students and the principles underlying the solutions. The problem situations are not necessarily very complex, nor is there always much mathematics to be done. The situations do require straight and original thinking and often there are alternative ways of proceeding. There is plenty of opportunity for exercise of ingenuity, particularly in planning which of several approaches may be best, in executing the plan, in devising checks and in interpreting the results of the mathematical solution.

Example of a Problem in Engineering Analysis

To make the foregoing clearer, consider an example. The senior mechanical

*"Teaching Methods in Engineering Analysis," B. R. Teare, Jr., *Journal of Engineering Education*, Vol. 35, June 1945, pp. 599–604.

engineering student is asked to predict from design information how long it will take a fan driven by a direct-connected induction motor to come up to full speed after the motor is energized. The information available includes, besides irrelevant things, the torque-speed curves of the motor and of the fan in graphical or tabulated form, and the moments of inertia of the rotating parts.

After some cogitation the student will realize that information on induction motors recently acquired in his electrical engineering minor course is not going to help him. Neither is what he has learned about fans in his fluid mechanics course of any use. He must find that the fundamental principle that governs the solution of the problem is something learned in elementary dynamics a year or two earlier and which he now must apply by himself, perhaps for the first time really on his own. The idea he needs to express is, of course, that the summation of the torques acting must equal the product of angular acceleration and the combined moment of inertia of the rotating parts.

Reducing this to symbolism, the student might write

$$T_M(\omega) - T_F(\omega) = I \frac{d\omega}{dt}$$

where $T_M(\omega)$ is the torque developed by the motor as a function of speed; $T_F(\omega)$ is the torque required to drive the fan, also a function of speed; I is the combined moment of inertia of the rotating parts; ω is the angular speed; t is the time.

Now comes the question of how to solve this differential equation, and, if the student has just studied graphical and numerical methods, it would be very easy for him. If he has not had such experience, the student must exercise his ingenuity; he must consider the fundamental things he knows about differential equations and then contrive a plan for solving this one. If on the other hand he is familiar with graphical and numerical solutions the problem is not appropriate for the purposes of the course.

A student thinking too hastily can go wrong by working with average values of torque if he uses the average with respect to speed which is easy to find, but, unfortunately, not right for the purpose at hand. A more careful student may decide to solve the equation for the slope $d\omega/dt$, and then step by step calculate the whole curve of speed versus time. In doing this he must decide how small to take the increments of time, and he has opportunity to exercise his ingenuity in arranging the calculations so that they will be easy to perform. Or, he may perhaps devise a semi-graphical procedure for stepping his way along the curve. A student who is possibly more ingenious may decide to separate the variables in his differential equation and find t to reach any speed ω as an area under the curve of $I/(T_M - T_F)$ plotted against ω. In finding the area, there are numerous alternatives open. The student may decide to work analytically using Simpson's rule, or by fitting the curve with an empirical formula; or, he may decide to plot the curve to scale and use a planimeter, or perhaps simply count squares to find the area.

Having found in some way a curve connecting ω and t, the student must consider what it means. If he has worked carefully, he will have found that he cannot determine how long the fan will take to reach full speed for this speed is approached asymptotically. As is the case with so many real problems, he finds long after he thought he had his problem defined, that to get a useful answer, he must change the original question; in this case, perhaps, to "how long will it take the fan to reach 95 per cent of full speed?"

Then the student must assure himself that what he has done is sound. He must study his work to see what assumptions he has made, and how they may effect his result. For instance in the case I have discussed, the student has not taken account of bearing friction torques ex-

plicitly. Are they already accounted for in the torque-speed curves he has used? How about the torque to accelerate the air in the system? Are electrical transients perhaps important? In each of the problems assigned him, the student is taught to study his own work critically by raising such questions as these and then devising ways of answering them.

The student is made to check his work in every way. Dimensional checks and arithmetic checks are obvious. Other kinds of checks are less easy and are a fertile field for exercising ingenuity. In the example cited, a reasonably independent overall check may be had by basing a simple calculation on averages of torque with respect to speed, which, even though inaccurate, serves to give the order of magnitude of the result. An enterprising student may check an analytical result by means of a laboratory measurement of his own devising.

Employ Basic Concepts of Fundamental Engineering Knowledge

By way of generalization, consider what characterizes the problem which I have discussed and the others used in Engineering Analysis. In doing this, it is important to view the problem in relation to the experience of the student, and the circumstances under which he is asked to solve it. First, observe that the problem is not subject to solution by substitution in a formula, nor is it given to the student as an exercise to be done after he sees how someone else attacks a nearly similar situation. Rather, it comes as something entirely new and unheralded, and the student himself needs to select from his total store of fundamental engineering knowledge two basic concepts and adapt them to his purpose. These two concepts are the law for angular acceleration of a rigid body about a fixed axis, and a really basic understanding of the meaning either of a differential equation or of an integral. It is important, considering the knowledge which the student may have at his command, that he be confronted with the possibility of alternative means for solution, none of which he can use without adaptation. As a result, the student has an opportunity to search out what he knows that is pertinent and adapt it to his needs, and being able to do this is the essence of inventiveness or ingenuity. To encourage the student in this direction the instructor, of course, must be very tolerant of the round-about and bungling procedures which students are likely to follow as they first learn to go ahead by themselves.

Finally, contrast such a course in Engineering Analysis with an engineering course in which development of subject matter is the objective. In the subject-matter course the student must master new material or new methods. At such a stage of the student's learning there is, from his point of view, only one sensible way to proceed—to apply what he is being taught. Indeed, if instead of doing this, he exercises his inventive talents by trying to devise some less elegant method of his own, he is likely to be rewarded unkindly by a low grade. A course whose objective is new subject matter cannot reasonably be expected to do much toward encouraging ingenuity, for at this stage of learning, the student can know only one good way to proceed. A course in Engineering Analysis, on the other hand, need have no objective beyond developing the power to deal successfully with new and unfamiliar problems. By confronting the student with interesting and challenging situations which are reasonably within his range of experience, he becomes ingenious in applying what he knows, and, above everything, he attains in this way a real understanding of what he knows. My experience shows that students are enthusiastic about such courses, and that, given half a chance, they will exercise an extraordinary degree of ingenuity.

"And Who Knows Whether You Have Not Come to the Kingdom for Such a Time as This?"*

By W. L. EVERITT

Dean of Engineering, University of Illinois

Vice President of ASEE

A year ago at the combined dinner meeting of the Liberal Arts and Engineering Divisions of the Land-Grant Association, my good friend Harlan Hatcher gave a stimulating talk on "What an Engineer Ought to Know." He summed up his speech at the end by saying "an engineer ought to know just about everything." A logical reply might well be "What the Humanist Ought to Know." Alternately, I might defend the engineer and explain why we are so human and at the same time so realistic that we doubt if we will ever attain his admirable goal.

One point on which engineers are willing to go all the way with our friends in Liberal Arts is the need for developing in our students an adequate facility in communication, both verbal and written, not only among ourselves but also with our fellowmen in all walks of life. I would like to enter a plea for a more human and less mechanistic approach to the teaching of verbal communication.

Students, like other people, are apt to learn more from a model than from critics. I like the vivid and succint language used by an English professor who rode a roller coaster for the first time. Asked by a friend to describe the experience, he said, "You have just had time to recite the prologue to Chaucer's Canterbury Tales—when suddenly all hell breaks loose." Is it not true that the first requirement of effective communication, verbal or written, is to develop in the listener or reader an interest in what the communicator has to say or has written? Cannot more emphasis be given in our rhetoric courses to the importance of developing *interest*? If the student has stopped to think of what appeals to the listener, first and foremost, he will have an incentive to develop both better grammar and better unity and emphasis in his writing and in his speech. It can be made obvious to him that if he uses poor grammar he will not be able to interest educated men in his words.

This approach should also enable us to develop in the freshman a recognition of the need for other studies in the humanities and social sciences, because it should be easy to show him that in order to interest others he must understand the background and culture of his listeners, and this requires continued education in many fields. Too often our students are frightened away from the social and humanistic areas by their teachers of rhetoric. These men and women have one of the greatest opportunities of all to initiate an interest in a broad intellectual outlook. This would also lead to the recognition of the importance of empathy, an appreciation for the viewpoint of others—something all men need

* Talk before Joint Dinner of Liberal Arts and Engineering Divisions, Association of Land-Grant Colleges and Universities, November 16, 1954.

today, and a word which is heard all too seldom.

If, on the other hand, we must stimulate the student by appealing to his selfishness, he can also be made to realize that his own progress will be determined largely by how he interests others in his ideas, and the most important of these "others" are apt to be men of culture, who will judge him by the form as well as the content of what he has to say.

If it is true that communication requires the development of interest on the part of the listener, is it not a paradox that our courses in the art of communication are quite generally considered by students (and not merely by engineering students) to be uninteresting?

But I did not come here tonight to criticize, rather I am here to explore how we may work together. This means that we should be friends. It also means that we must be perfectly frank with each other if we are to achieve real cooperation.

Need for Cooperation

Our need for cooperation is emphasized by our present peril. Peril is not new to the human race. Someone has said that the trouble with each generation is that it hasn't read the minutes of the previous meeting. In history we have many examples of perilous times. Sometimes the intellectual climate has produced statesmen who have led the people out of their troubles to greatness, and at other times such statesmen have been lacking. As an example in our own American history, consider the period of the late Eighteenth Century when our nation was founded. Our constitution was written and adopted and thirteen antagonistic colonies were welded into a nation. Contrast this period of the late Eighteenth Century with the 1850s, when there was a widening chasm between proslavery and antislavery publicists and literary men, and when fanaticism on both sides replaced reason. Lincoln and Lee stand out particularly because of the drabness and mental mediocrity of their associates. When one was defeated and the other was assassinated, there was no one left to provide adequate leadership. In the reconstruction period, statesmen and men of good will were notably lacking or ineffectual.

In spite of criticism and anti-intellectualism, there has probably been no previous era in which so much faith has been placed by the people in education and in educators. Furthermore, while in previous centuries, scientists and engineers generally did not make, and were not expected to make, contributions to the solution of political problems, it is doubtful if people today would accept conclusions unless they were based upon a proper understanding of modern technology.

This places a great responsibility upon all of us. I am sure you are all familiar with the story in the Book of Esther. At that time a whole people were threatened with total destruction, for King Ahasuerus had been persuaded by his Prime Minister Haman to issue an edict, and I quote from the words of the third chapter: "to destroy, to slay and to annihilate all Jews, young and old, women and children in one day, and to plunder their goods." To that people the threat was just as real, just as terrible—probably even more real and terrible than any thermonucleonic bomb is to us. In this emergency, Mordecai presuaded his niece Esther, at peril of her life, to intercede with the king, saying in Esther 4:14, "And who knows whether you have not come to the kingdom for such a time as this?" In times like this I ask the same question of our intellectual leaders—humanists, engineers, scientists, lawyers, political scientists, political practitioners—and most especially of such leaders who are functioning in our educational institutions.

I wish that I could come before you tonight with a well-worked-out and integrated plan which I could believe would solve our problem. Even more, I wish that I could have faith that a committee

or a conference participated in by all our disciplines could produce such a plan. But I have no such hope that we can work out *farseeing* plans to which events will conform. With both the physical and the political world moving as rapidly as they do today, we must work for intellectual flexibility coupled with wisdom rather than for the long-range foresight of the soothsayer.

It has been said that in recent years we do not have a signing off of wars, but only short pauses for enemy identification. Some think this enemy identification is simple, as in each period of history men have thought it simple because they could point to external tribes or nations planning or waging war against them. But can we assume that our enemies are only specific foreign nations or domestic subversive groups? The most dangerous enemies are those who are not recognized, particularly if they are among ourselves. They may include, to list just a few—ignorance, rigidity of thinking, intellectual snobbishness, personal indulgence posing as scholarship, lack of understanding, yes, lack of empathy. Even in a world of uncertainty we can attack these enemies now; we do not have to wait for them to declare war on us. Are we as a group going to be part of the problem, or part of the answer? We cannot be part of the answer if we are indifferent, lazy, or mere handwringers. We must take a positive approach.

First of all, collaboration of all men of good will is now essential. There is no time left for controversies among disciplines or professions. There is no time left for mere crying over our own or others' past mistakes.

This collaboration must be sincere rather than superficial. The integrity of each discipline and vocation must be preserved, while at the same time each must search its soul. In engineering education we are doing this assiduously, as I am sure you in the Liberal Arts are, too. One example of the self-analysis of engineering education is the current study on Evaluation of Engineering Education by a committee of the American Society for Engineering Education under the leadership of Dean Grinter. I hope some of our Liberal Arts friends will take time to read the report and, if they care to, give us criticisms of it.

New Frontiers

It is perhaps trite to say we are on new frontiers; the world has always had new frontiers. It is also commonplace to say that our new frontiers are intellectual rather than geographical. However, for a moment let us consider some of the challenges that a frontier always presents. In the opening of geographical frontiers one can distinguish between the adventurer, the explorer, and the frontiersman. The adventurer is one who is interested primarily in thrills—a dilettante as it were, who thinks only of himself. Such selfish adventurers are common in intellectual frontiers. On the other hand, the explorer is one who goes into new territory and then returns to the world from which he left to tell about it. His explorations are useful if he leaves a record which can be understood. Only a few explorers are needed in each generation, but their contribution is a most important one. On the other hand, the frontiersman is an individual who goes into a territory expecting to stay and make it his own—to become a part of its life. He expects to develop the new territory for the use of mankind and reduce the wilderness to permanent usefulness. Our universities require for their continued existence both explorers and frontiersmen, although the colleges do not have a monopoly on such individuals.

Let us consider some of the characteristics of the frontiersman.

(1) He needs initiative; like the explorer he will also have an urge to explore.

(2) Closely associated with this initiative is resourcefulness—the ability to adapt himself to new situations.

(3) The frontiersman must be versatile. There is no place in his life for juris-

dictional disputes; he has to be carpenter, hunter, stone mason, farmer, and so forth, and so forth. This versatility is needed on the intellectual frontier also.

(4) He must be flexible. New situations continually appear which he cannot foresee.

(5) He must have courage. In this connection he should clearly distinguish between courage and foolhardiness, so he must have good judgment.

(6) He should have common sense. Karl Compton's sister, whom you may know was married to the head of a missionary institution in India, once had an electrician who was wiring the house. She tried to explain to him something that she wanted, and when he did not understand, she said, "Oh, you know what I mean, just use your common sense," to which the artisan replied, "Madam, common sense is a gift of God; I have only a technical training."

(7) He must be cooperative. While the frontiersman must be willing to strike out alone, he has to work with his neighbors because the peril of the frontier calls for joint efforts of protection, both against human enemies and against the forces of nature.

(8) Above all, the frontiersman has to be a builder, a man who knows he is master both of his own fate and that of others, and his eye must be on the future rather than on the past.

What are some of the objectives our individual groups should undertake? First let me address the engineers.

(1) We should develop a much keener historical sense. It is certainly far more important to understand history and its implications than merely to place events in a chronological order.

(2) We should recognize, and try to transcend, the limitations of our own disciplines. We rather properly place great faith in the so-called "engineering method," but we tend to assume that it can provide a solution to all problems. We must recognize that many men (including engineers) often make decisions on the basis of intuition and emotions, and are not always persuaded by logic, particularly mathematical logic, or by arguments which are phrased in unfamiliar terms.

(3) We must attain a deeper understanding and greater participation in our political and economic life.

(4) We must acquire an appreciation for the cultures of other nations of the world with whom we must live on terms of equality and mutual understanding. Because engineers have played such a large part in the development of our American economy, it may be more difficult for us to understand other cultures.

(5) The engineer, who is a man of action, must, at the same time, learn to recognize the values of contemplation and philosophical speculation which are dear to the humanists.

On the other hand, I would like to urge our colleagues in the humanities and social sciences—

(1) To recognize that there is a true culture in both the thirst for knowledge of the physical world and in the desire of the engineer to "employ the forces and materials of nature for the use of mankind."

(2) To recognize that the rate of change in the world of physical sciences is such that time seems to be shrinking and, hence there is a need for a sense of urgency though not of panic.

(3) To accept sincerely, however reluctantly, the need for accelerated development of means of physical defense, and understand why such a large proportion of the efforts of the engineer and scientist must be employed in this direction. Do not think we are happy about this, but your safety as well as our depends upon our working on this at times behind locked doors, so that often we cannot even tell you what we are doing.

(4) To understand sincerely and to assist us in the solution of the very diffi-

cult problem we have in the education of our students. The rapid growth of our body of knowledge and the difficulty of knowing, as Harlan Hatcher suggested, just about everything, makes us always face a choice between the essential and the good.

(5) To recognize that in the physical and engineering sciences, more than in other fields, the highest productivity appears to occur at a relatively early age, and so we cannot delay too long the time at which our men pass from the student to the productive stage.

Common Problems

Common problems for both groups include the necessity of making unselfish and rational judgments as to staff, curricula, and methods necessary to give an education which shall save us from our enemies and, at the same time, preserve those values which are necessary for men to be truly free. In our programs we must continually study what is important; I should say, what is most important, for we may not be able to afford the luxury of giving to our students all that is good, but may have to concentrate on that which is best and in some cases on that which is essential. Having studied searchingly the contributions we and our fellows in other disciplines and vocations can make, we must pool our resources to attempt to bind together the free nations of the world both materially and spiritually. In doing this we must avoid both the Scylla of trying to force on them political and economic concepts and practices that are adapted primarily to our own nation, and the Charybdis of indifference to their need for technical and material aid.

Finally, we must preserve in this country what our carefully-reasoned judgments assure us are the liberties without which our way of life is not worth defending. We must also try to carry behind the Iron Curtain an honest persuasive picture of both the material and the intangible values common to the free world, neither deprecating nor exaggerating the role of the United States as an exemplar of those values.

And who knows but what we have come to the kingdom for such a time and such a task as this?

Sections and Branches

The 1954 annual meeting of the **Rocky Mountain Section** of the ASEE was held May 14–15, 1954, on the campus of the University of Utah, Salt Lake City, Utah.

The Nominating Committee presented the following slate to the members at the business meeting: *Chairman,* D. F. Peterson; *Vice Chairman,* William Parks; *Secretary,* D. N. Zwiep; *Member of Council,* A. Diefendorf. A motion was made, seconded, and carried that the secretary should record a unanimous ballot.

Brigham Young University was invited to participate with the schools currently active in regional activities of the Society. Responding for Brigham Young University, Harvey Fletcher expressed thanks for the invitation, and stated that his school should be ready to participate fully by 1957. D. N. Zwiep, representing Colorado A. and M. College, invited the section to meet at Colorado A. and M. in 1955. The invitation was accepted by unanimous vote. The chairman appointed J. T. Strate, A. L. Gosman, and N. W. Ryan as a committee to recommend (a) a scheme for rotating places of meeting, with Brigham Young University included as a participating school, and (b) a scheme for rotating the office of Member of Council among the participating schools.

Vibration Problems*

By JAMES J. RYAN

Professor of Mechanical Engineering, University of Minnesota, and General Mills, Inc., Minneapolis, Minnesota

Synopsis

Recent experiences with engineers in the field indicate that problems in vibration have increased in number and complexity. In design, the analysis may anticipate the vibration difficulties by reducing the possible disturbances or by removing resonance from the structures. In operation, from the measurement of the vibrations, methods of correction are often suggested.

The discussion will develop the steps in the teaching procedures, and the type of vibration problems for students in design courses from the elementary to the specialized graduate class.

The approach suggested in this educational survey is that certain things must be unconditionally understood (known). To this background of fact, theoretical and experimental, each step is added depending upon the time available for additional study. Thus the *few* fundamental factors may be so thoroughly impressed upon the student that he can never forget, and he may always start with a basic viewpoint.

Problems of importance in present day design include the old ones on shaft critical speeds, structural resonance, and vibration transmission; and the new ones on shock mounting for impacts, resonance in control systems, effects of damping characteristics on impulses other than sinisoidal, and the present vibration and impact requirements of government specifications.

Introduction

Modern practice in the teaching of *Vibration Problems* is a combination of the instructor's acquaintance with the basic information which the students have had in previous courses, and his understanding of the common problems in vibration encountered by the engineer of the present. When these two elements are brought together they form a useful body of knowledge to be assimilated by the student. Perhaps the only excuse for the study of *Vibration Problems* is the opportunity the student has to re-learn statics, dynamics, strength of materials, basic mathematics, calculus, and differential equations—made possible by this type of application. Thus it may be observed that the ability to solve problems in vibration is not the principal purpose of these courses, but rather the application of the earlier studies in a new and constructive manner.

It is apparently necessary, therefore, for the student to absolutely know the basic ideas involved in simple *Vibration Problems*—and to be able to develop the solutions without recourse to notes or textbooks. The physical tie between the vibration phenomena and the mathematical interpretation should be thoroughly understood. Thus the student has a definite picture of the conditions of vibration, and the mathematical equivalents which describe the motion. Any of us can write down the equations of equilibrium involved in vibration problems, but the most important function in teaching is

* Presented at the Summer School, Machine Design and Manufacturing Sub-Division, American Society for Engineering Education, University of Illinois, Navy Pier, Chicago, Illinois, June 23, 1954.

for the student to absolutely understand the physical conditions that are displayed by these equations. The difference between knowing and memorizing must be discerned.

The next step, in the study of *Vibration Problems,* is the procedure by which the development progresses from simple motions to more complex ones. This is the coordination, through definition, of the phenomena observed and the mathematical analysis. The third step involves the solution of a number of problems which are representative of both the elementary and the complex vibrations, to obtain some degree of skill and familiarity. The fourth step is the study of analogies, and of equivalent systems which may be useful in repetitive calculations for industrial studies.

At the present time, however, the study of *Vibration Problems* has assumed a more important nature due to government requirements, which are concerned with the industrial problems of fatigue and the malfunctions of instrumentation. Requirements of resistance to high impact, improved control at critical speeds, and the effect of various impulses other than simple harmonic require the student to have a very basic knowledge of the interpretation of simple vibration phenomena.

Teaching Procedures

The teaching procedures, with adequate textbook and lecture support, require that the student be able to develop by himself, without references, the basic equations that are involved in the fundamentals of vibration. Thus each problem is worked out by first developing the equations for the conditions of the problem, and then, when supplied with representative data, numerical solutions are made for the required information. This approach may be rather difficult for students who are in the embryo process of learning how to analyze a problem. It is also hard on teachers, since they must know how to develop the steps and solve the problems—not only the immediate ones, but all the variations which are suggested by the students in their intimate acquaintance with these elementary concepts. This teaching philosophy is based upon the concept that it is better to absolutely know a little than to grope hesitatingly through a mass of information which can only be assimilated by an intimate knowledge.

In the normal study of *Vibration Problems* there are only a few elements which must be absolutely known. These are the equivalence of forces in motion, the effect of the damping factor, the phenomena under critical conditions which change the angles of lag, the magnification factors of the amplitudes of motion above and below the critical speeds, the concept of vibration transmission and absorption, the process of balancing, the test methods for determining natural frequencies, and the use of instruments in the measurement of vibration.

To illustrate that it is easy for students to work out *Vibration Problems* without understanding the mechanics involved, a test was given to a graduate group quite well along in the vibrations course. They were told that in coming to work that morning I bumped the car ahead severely on stopping at an intersection. The bumpers of the car locked and due to the impact, resonant vibration occurred. Knowing the weight of the cars and the spring constants of the bumpers, I suggested they calculate the natural frequency at which the cars vibrated. It was very disappointing to find that no one in this large advanced class was able to correlate the facts of life with the necessary analysis. Thus it behooves us as teachers to teach the fundamental elements of vibration, and to supply practical problems for a better understanding of the mechanics and mathematics involved.

Laboratory Models

In our vibration laboratory are a number of operating models which are used to supplement the student's interest and understanding of the somewhat complex motions under study. The students are often given the physical factors related

to these models, and asked to make vibration calculations based upon the physical dimensions. Tests are then made of the actual operation of the models, and the results of the calculations and the measurements are compared.

The several balancing machines in the laboratory are sometimes used to balance high speed equipment in the area. The actual procedure of balancing of these machines is often observed by the students.

The sound film, "The Mechanics of Vibration" was produced in the Machine Design Laboratory for the purpose of demonstrating the basic elements of vibration, since it is difficult to maintain the models in satisfactory operation. Copies of this film are available at the University of Minnesota. It might be of interest to show this film at the conclusion of the discussion.

Outline of Advanced Vibration Material

The present requirements of industry have stepped up the knowledge required by students in solving *Vibration Problems.* The following list is a sequence of topics based on the actual needs of industry, beginning with the more elementary problems and continuing to the most complex:

1. Free vibration observed in critical speeds and balancing.
2. Damped vibration of instruments on shock mounts.
3. Shake table analysis of natural frequencies and fatigue failures.
4. The determination of torsional critical speeds.
5. Use of instruments in the measurement of vibration.
6. Determination of the effect of G-loadings on equipment.
7. Interpretation of displacement, velocity, and acceleration measurements.
8. The analysis of simple harmonic, square and triangular impulses, and applications to impact.

The purpose of *Vibration Problems* is to illustrate the lectures and textbook material with applications in the solution of normal vibration difficulties.

References

There are a great number of textbooks available with reference material to be given to students in vibration courses. Many teachers prefer to use the problems outlined in textbooks. However, the lack of mental stimuli is often encountered in solving these problems, and sometimes the exercise consists of mere substitution. It is usually more profitable to make up problems based on the immediate discussion and student interest. Sometimes these go beyond the ability of both the students and the teacher, but the attempt is made to tie the information together in an understandable manner.

On the job information is easily gleaned from textbooks and technical papers, and it is quite convenient for the engineer to look up the required vibration equation or a problem that is similar for comparative examination. However, in the average case, an adequate similarity does not exist, and the basic knowledge of the mechanics and mathematics results not only in a solution but also in a much better understanding of the problem.

Conclusions

In summary, it might be stated that the study of *Vibration Problems* is basically for the purpose of understanding the application of mechanics and mathematics to practical problems. This can best be accomplished by a fundamental understanding of the development of the equations which express, in understandable language, the phenomena involved. Not only is this approach useful in the elementary studies of undergraduate courses, but also for advanced graduate studies in the theory of vibrations.

A thorough understanding, even though at various levels, contributes to the effective analysis of *Vibration Problems* in the field, and makes more valuable the work and the resulting satisfaction of the practicing engineer.

How Should Exams Be Graded?

By R. L. SANKS

Assistant Professor of Civil Engineering, University of Utah

How should exams be graded? This question can hardly be answered until we define the aims of education and the role of examinations in the promotion of those aims. Certainly no one would deny that these aims are training in reasoning, responsibility, theoretical and applied mechanics, and general information. Examinations, even among graduate students, are almost indispensable as teaching aids, and as such, they should be designed and administered so that the above aims are not only measured but actually taught. Some instructors see in an examination only a device to separate the A's from the C's, and, like the poor, these will always be with us. But happily most instructors realize that examinations are more than mere proving grounds, that they can provide instruction as well, and that the latter function is of much greater importance than the former.

Instruction by Examination

If examinations are to be used as educational aids, they should be given at frequent intervals; one midterm and one final seems hardly sufficient unless supplemented by several shorter quizzes. In "problems" courses of two or more credit hours, the lecture time lost in three one-hour examinations during the quarter is more than balanced by the benefits accruing from the exams.

Theory and—to some extent—reasoning can be taught by making the exam problems comprehensive and by making many of them difficult and of a somewhat new and different nature from the problems assigned for homework. Students cannot work such problems by rote and must of necessity understand the underlying theory to even begin an attack.

Training students in responsibility is of utmost importance. There appears to be a general decline in responsibility and self-reliance. Specific evidence is not hard to come by: soaring juvenile delinquency, the world-wide movement towards the welfare state where everyone —worker or drone—will receive nearly equal benefits, the carping of pseudo-psychologists who indoctrinate us with the belief that society is to blame for our shortcomings. When irresponsibility is being excused and even condoned, certainly we should be vigilant in this phase of the educational program. I can safely leave it to your imagination to picture the chaos that would follow a general abandonment of professional responsibility by engineers. Who would condone a consulting engineer who has designed a failure and excuses himself by saying, "But my theory was correct. I only forgot to divide by two."?

There seems to be a widespread misconception in the minds of students to the effect that "someone" will always check their computations, and more often than not I have found that students have little respect for arithmetic. It is true that occasionally the most important computations are checked, but it has been my experience and observation supported by that of almost all engineers of my acquaintance that nearly all calculations are not formally checked and that the engineer must stand alone in his responsibility for them. When shall he begin to

learn his responsibilities? Shall we nurture him through school, giving him part credit and an implied pat on the back for getting his theory correct but his answers wrong? Shall we let him unsuspectingly enter industry fatuous in his belief that if his approach is correct naught else matters? And when his rude awakening comes and he learns that industry expects only correct answers, will he rightly blame our educational myopia for sending him unprepared into the world?

I submit that the time to learn the responsibility of accuracy is in grade school and all through high school and college students should expect to be graded on the basis of their results. Lacking control over grade school and high school examinations we can still accomplish a great deal in college. Even though accuracy is only one phase of responsibility, still it is very important. Of course, correct answers alone are not significant; all the arithmetic, mechanics, and theory that lead to the answer must be correct also. Certainly no credit is due a student who, by a series of fantastic blunders or compensating mistakes, stumbles onto the right answer quite by chance.

Grading on Answers

It should be self-evident that if exams are to be graded on answer (i.e., correct theory, application, and arithmetic leading to correct answer), the exams must be designed with that in mind. No thinking person would advocate so grading a long, difficult, and involved exam consisting of a single problem. Anyone might make an occasional mistake; so if we wish to eliminate the element of chance, we must make up exams consisting of several problems with each problem subdivided into several parts. With care and intelligence we can make such exams as difficult, comprehensive, and as illustrative of basic theory as desired, and it can be done in such a way that one early mistake does not imperil the whole exam or even the entire problem. Thus the student is not damned, but only justly penalized, for making a mistake. If many exam problems, so subdivided, are given, the student has just as good a statistical chance to make a good grade as he would have under any other system.

The grading must also be tailored to the new system. A test score of 50 per cent under this system might compare favorably with one of 90 per cent under some other grading method. Each instructor must fit his grading to the difficulty of the exams, and therefore, there will be no more low grades under the new system than under any other.

I, too, once felt this system would be unfair and that grades based upon it would not be truly indicative. Much thought and discussion with practicing engineers and industrialists convinced me that accuracy was important enough to justify a trial. Three years of experimentation has convinced me that it is fair and equitable, that it results in significant improvements in students' accuracy, and that as an indicator of student ability it is as good as any other system of grading.

In order to test the idea that exams graded by this system are indicative, one class became a "guinea-pig." The course was Indeterminate Structural Analysis and the subject matter was Moment-Area, Virtual Work, and Moment Distribution applied to find deflections, moments, and reactions of simple to fairly complex structures—a difficult, hard-to-understand, theoretical course in mechanics. Exams were designed so that they could be and were graded by answer only and also by half credit for correct theory. There were six weekly quizzes of one problem each and five problems in the final exam. All problems consisted of two or more parts, the answers of each usually independent of the other.

Fig. 1 shows the percentile scores as obtained from each system of grading. Note that the correlation is excellent except for students 1, 2, and 10. The final grades appear to be based on the grading system of half credit for theory. Actually

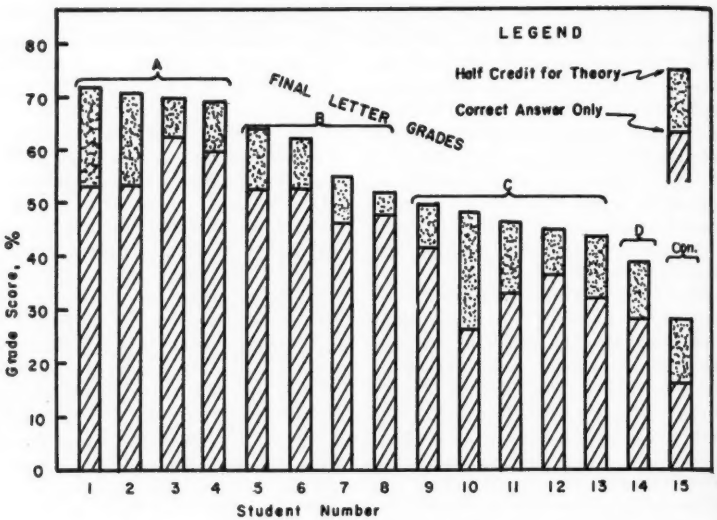


FIG. 1. Correlation between two systems of grading

two sets of grades were made and where any discrepancy occurred (as with students 1, 2, and 10) the student was given the higher grade, largely because the course was so difficult and the instructor so softhearted. But there is no reason to suppose that students were given the most appropriate grade; grades could have been based on answer only (in which case students 1 and 2 would have received "B"s and student 10, a "D") with fully as much justification.

Criticism

It was to be expected that such a system of grading would be roundly criticized, especially by the students. Most students resent this system at their first contact with it. Some have denounced it bitterly with fire in their eyes and, no doubt, murder in their hearts, but those same students have voiced their complete approval of it after they have had a quarter's experience with it. Many have told me that they feel it is the *only* way to grade and that it should be universal.* However distasteful it may be, students are unanimous in feeling that this grading system is good for them, improves their accuracy, makes them more mature, and impresses upon them an appreciation of responsibility.

There are several points of criticism usually raised indignantly by other instructors and by students. These and the answers to them follow.

It is unfair! No one has ever devised a test that is perfectly fair; that is, one that will give a true measure of the student's knowledge and ability. Fairness, then, must be considered a relative term.

If many problems are given so that the grade does not depend upon a chance error, this system is as fair as any. If a student consistently makes arithmetical mistakes scoring zero on all the tests, he has an ingrained sense of inaccuracy and

* This is not "apple-polishing." Student opinions are not quoted if voiced before final grades are given and before all courses with the instructor are completed.

would be as worthless in industry as he is as a student.

Perhaps we should not be so greatly concerned with fairness anyway. Our main purpose is to educate future engineers. Grades are not of primary importance, for no one has ever shown that there is a perfect correlation between grades and success or ability as an engineer. It is unfortunate that they have received attention far out of their true value in educational society.

It emphasizes arithmetic and de-emphasizes theory! On the contrary, nothing could be farther from the truth. It must be obvious that no problem can be correctly worked unless the theory is also correct. Furthermore, theory is emphasized even more than it is under a different grading system for two reasons. First, there is no room at all for muddy thinking. If part credit is given for theory, a student can get some credit if a part of his theory is wrong. However, under the proposed system, he gets no cerdit at all; so theory is therefore emphasized to such extent that all of it must be correct. Second, the student must give a good deal of attention to accuracy; so because his mind is partially diverted, it is mandatory that he know his theory even better than would be necessary under another system.

It should be noted that, under this system, students do not often make arithmetical mistakes. Ordinarily, arithmetical blunders account for about 10 per cent of the mistakes made. The students are, of course, very careful with arithmetic; so their mistakes are primarily those of application of theory.

The pressure in a test is not found in industry where calculations can always be checked! The implication is that it is manifestly unfair to expect accuracy under the "artificial" conditions of a test, and that in industry these conditions of extreme pressure do not exist. This cry of anguish comes only from the inexperienced. What *practicing* engineer has never worked at top speed for many hours and even days or weeks to meet a deadline? True, the tempo of the test may not be duplicated, but that is more than compensated for by the length of time involved. It is much more difficult to avoid a mistake over, say, a two-day period than it is over a two-hour period.

Although much engineering work is checked as a matter of course, probably most of it is not. And, more often than not, the engineer must check his own work, and this the student can do in his exams.

This grading system penalizes students with little native ability in accuracy! Accuracy is not an inbred ability; it is a habit. Basically it is a by-product of complete concentration. It is essentially carefulness and craftsmanship. It can be learned like any other skill, and if not practiced constantly, it can be lost. There is no such thing as a native ability in accuracy. If students are forced to learn accuracy, they will do so, and their employers will be vastly more satisfied with their services.

Conclusions

The most important conclusions to be drawn from this discussion are as follows:

1. A grading system based upon no credit for inaccuracies is as fair and equitable a yardstick as any other for determining a student's grade.

2. To be fair and indicative, both the examination problems and the grading standards must be tailored to fit the grading system.

3. Such a grading system emphasizes correct theory while placing a premium on accuracy.

4. The student learns to be responsible for his work and acquires an appreciation of the obligations of the trust placed in him by his employer.

5. Students are trained in carefulness, accuracy, and craftsmanship.

6. Industry will be greatly benefited by acquiring young engineers with the training in responsibility which can only be offered in a system of grading based on no credit for incorrect work.

Stress the Fundamentals—Applied

By DAVID I. COOK

Assistant Professor of Engineering Mechanics, University of Nebraska

The ever expanding field of engineering and the resulting trend to specialization subjects us to new responsibilities as teachers. It is our obligation to place before the student those things which we believe will be of most value to him in the profession in years hence. If we had the gift of prophesy and could say, for example, "John Smith, you will be designing surface controls for rocket ships in 1970," a program of studies could be tailormade for each particular student. Unfortunately such is not the case, and we know that a high percentage of the information supplied the student will never be used. We will be shirking our duty if we fail to scrutinize continually the subject matter in our courses, discarding the obsolete, retaining the unchangeable, and adding the new, to keep abreast of recent developments.

New developments in the field should be presented to the student to promote his interest in the subject matter and keep the course "alive." Considerable care should be exercised in such presentation, however, so that details of the development do not obscure the underlying physical principles involved. For each new development will in time become obsoleted by one more recent. Only the principles will remain unchanged. These underlying principles or engineering fundamentals should, therefore, be emphasized above new and more detailed or specialized material.

Every course we offer contains certain elements which can be considered as being fundamental to the subject. In engineering drawing we teach students to represent three-dimensional objects on two dimensional paper. Fundamental to this subject are the orthographic view, the pictorial view, geometric constructions, and elemental shapes. Recent developments in simplified drafting, new drawing and drafting room standards being completed, and a unification between United States and Great Britain of screw threads and classes of fit, provide ample opportunity to introduce new material in engineering drawing courses.

There is danger that with this wealth of new subject matter, which is of particular interest to the instructor, the principles of orthographic projection will be slighted. What good are simplified thread symbols which appear on an oblique view, if the view itself cannot be drawn?

In descriptive geometry we teach the student to find the intersection of surfaces and to show views of surfaces in specified directions. For simplicity, it is common practice to represent such surfaces by triangles. If we give a problem in which an odd shaped bracket or clip is to be represented, a surprisingly small number of students will recognize the principles of descriptive geometry involved. Most of them will be unable to proceed directly with the solution without some coaching. Here is evidence that between the theoretical principle and the practical application is a gap that should be cause for concern.

In engineering statics we teach students to calculate the forces present in engineering structures and machines. The fundamental equations of statics are easily explained and easily understood by the student. The mathematical relations commonly used in statics are relatively simple. Difficulty in the subject arises, as

in the case of descriptive geometry, in applying the theoretical relations to a practical problem.

In engineering kinematics and mechanism we teach the student to analyze the motion of a machine, determining velocities and accelerations at different points. But if we go a step further and ask for the forces on the crank pin and cross head, he will have difficulty in finding them. There is a gap between the theoretical constructions and the actual forces acting, which is a pitfall for many students.

An engineering student taking a course in differential equations will find the majority of problems consisting of a mathematical relation which is to be changed, using derived relations and algebra, into a form which can be integrated, the integration then being performed by the use of tables. The student will have little difficulty in solving most problems. If, however, the problem is to find the period of oscillation of a weight supported by a spring, he will, in many cases, be unable to set up the differential equation for the motion.

Must Teach Fundamentals in an Applied Form

The point I wish to emphasize is this. We teach the fundamentals to a student, but if we expect him to apply them, we must teach them in an applied form. Engineering is an *applied* science. The majority of our graduates will be required to solve applied problems, and our teaching should be for the majority.

One summer during a period of employment in industry, I recall several instances in which the fundamentals of mechanics were overlooked in an attempt to solve a practical problem. In one case an oscillating cylinder, operating as a shaker, was used to put a certain type of finish on small parts. The resulting vibrations carried through the floor of the building to sensitive instruments and precision machinery. It was proposed to add springs between the end of shaker and the bench top to "counteract the inertia of the cylinder at the end of its stroke." The effect of adding the springs would have been to transfer the force from a mounting bracket attached to the table, to a spring attached to the table. Failure to consider the table as the body which transferred vibrations to the floor and to consider the forces acting on both ends of the spring, constituted a violation of a fundamental principle of mechanics. Mounting two units in tandem so that opposing inertia effects would counterbalance each other finally solved the problem.

In another case a circular recess in a machine part was found to be stepped instead of flat as specified. The defect was believed to be caused by a dull cutting tool or worn bearings. The possibility of a deflection of the work support was overlooked entirely. One of the fundamentals of strength of materials, namely, that bodies deform under load, was not firmly established in an applied form in the mind of the person in charge of the operation. Strengthening the work support solved the problem.

This question naturally arises. How can we present course material to teach the fundamentals in an applied form? My answer is this. Review a given course and select the topics that may be considered fundamental to the subject. The process can be simplified by preparing an outline and carefully evaluating each topic as to permanent worth to the student and the amount of time it should receive. Select a textbook which contains many problems of a practical nature and finally, illustrate every principle presented in class by means of a practical application.

Our objective is to train young men to become engineers, practical men, who must learn to think along practical lines in an ever changing, rapidly expanding field, where the fundamentals alone remain unchanged. In order to provide a sound basis for practical reasoning, let us stress the fundamentals. In order to train the student to relate a basic physical law with a practical problem, let us stress the fundamentals—applied.

Teaching Tips

Conference Method in Laboratory Courses

By JOHN E. GIBSON

Instructor in Electrical Engineering, Dunham Laboratory, Yale University

One of the most difficult problems to solve in a laboratory course which must cover certain specified material is that of getting the students to efficiently use their time in the laboratory. One attempt at solving this problem is to give a detailed pre-lab lecture that points out all of the pitfalls and difficulties which may be encountered. Presumably this insures that the required amount of work will be accomplished in the allotted time, but it certainly is spoon-feeding with a vengeance since the lab is usually the only place where the student is asked to exercise his initiativve.

Another common solution is to pass out mimeographed material which covers the laboratory exercise in detail and which is in addition to the normal laboratory or recitation text asignment. Usually the student still walks into the laboratory cold. Even the threat of a short quiz on the reading material before the experiment only causes a few minutes of cramming before the quiz.

A plan has been evolved which encourages the student's initiative and at the same time permits completing the assigned material. No doubt similar methods have previously been used but since it is sound pedagogically and in addition actually works, perhaps it deserves to be noted.

The laboratory group is set up with a "group leader," an assignment which rotates from man to man. The "group-leader" plan has long been recognized as sound psychology as well as good experience for the students. However, in practice it sometimes fails due to the inexperience or timidity of the weak men in the group. The quicker men may resent having a slower man giving directions. Even if the slow man is conscientious and has prepared for his assignment (which is not always the case) the better men may argue with his decisions since they are not sure that he knows what he is talking about. Further, the instructor, if he is going to utilize the group leaders at all, will not give as detailed a lecture as he would otherwise. Thus the risk is run of the entire exercise failing.

These shortcomings may be eliminated by having the group leader meet with the laboratory instructor previous to the laboratory session to discuss all of the measurement techniques as well as the underlying theory. Since the group leader will personally and individually discuss the work with the instructor, it takes an extremely slip-shod individual to fail to make previous preparation for the interview.

The interview covers (1) a detailed discussion of measuring techniques, with actual circuits and connections drawn out on paper by the student *before* the interview. (2) The reason *why* the various readings are to be made. (3) What is to be done with the collected data.

The student must make advance preparation if he is to answer the various questions which the instructor may ask. If the leader does lack preparation, he

may be asked to make another appointment.

The results gained by instituting this system have been very gratifying. *First:* The group is ready to cooperate with the leader since they know that he has discussed the experiment with the instructor and that he actually knows what to do. *Second:* At least one student in the group knows what the aims of the experiment are and is able to see the forest without being confused by the trees. Of course the instructor points these things out in his pre-laboratory lecture but any teacher is ready to admit that the point is sometimes missed by the students. *Third:* Because of the organization, each man realizes that the experiment can be completed properly and on time. Thus the entire group works with a will and turns out much better work in less time.

While it would be admitted that this method *could* work, there are many factors which might cause it to fail. First: If the group knows that one man is responsible, are they not likely to lie down on the job? No. As a rule engineering students are interested in laboratory work and they want to do well unless they are discouraged by their own confusion (this desire is, however, not usually strong enough for them to reduce their confusion by adequate preparation). The occasional malingerer seems to be held in line by the fact that he will want cooperation when he becomes group leader.

Second: Isn't this going in the wrong direction, by only requiring *one* man to do any preparation? No, since the rule is that none of the men make much preparation. Furthermore the instructor still gives a pre-laboratory lecture to cover the theory. The lecture may be shortened since it need not concern itself with the practical details already discussed with the group leader.

Third: Can the slower men meet the challenge? Yes. In fact this one point makes the whole thing worth while. The first year that the conference method was tried by the author, it was introduced in the second semester. It was a real satisfaction to see those men who had gradually drifted into merely data taking during the first semester step in and take charge. This seems to be the best way of insuring that all of the men in the group progress together without hamepring the better men.

Fourth: Do the students like it and will they cooperate? Yes. Here are a few comments: "Good to have someone in the group who knows what has to be done," "Good experience," "We know that if we work, we can get out early" (a *very* powerful incentive).

Of course the conferences take up quite a bit of the instructor's time but the results are worth it. There is always the temptation to steer the laboratory experiments—perhaps because it salves the instructor's consicence—but experience has shown that this method will allow the material to be covered with the student still able to exercise his independence and ingenuity.

In the News

The **Engineering Societies Library** has prepared a Bibliography on Unionization of Professional Engineers to answer inquiries received by the Library from engineers, engineering students and others interested in the subject. The 100 references in the Bibliography are to pamphlets, and articles in magazines from 1937 to 1954 which are in the Engineering Societies Library.

ESL Bibliography No. 10: BIBLIOGRAPHY ON UNIONIZATION OF PROFESSIONAL ENGINEERS. 100 references. 8 p. Mimeographed. 1954. $2.00. Available from the Engineering Societies Library, 29 West 39th Street, New York 18, N. Y.

UPADI—What It Is, What It Does

UPADI—What it is: In Spanish it is the Union Pan Americana de Associaciones de Ingenieros. In English it is Pan American Federation of Engineering Societies. Initiated in Rio in 1949, about 18 nations have engineering organizations that are Members of UPADI and two other nations have organizations that are affiliated. Engineers Joint Council holds the membership for the United States. The headquarters is at present in Montevideo.

UPADI is an engineering organization which preserves the independence of member societies in their own activities and at the same time provides a new means for increased cooperation among engineers and industry of the Western Hemisphere. The objectives of promoting unity among engineers and progress in science and technology are obtained by encouraging, guiding and standardizing the efforts of engineers in the Americas; by holding periodic Pan American Engineering Congresses, Conventions and Exhibits; by encouraging travel of engineers among the American nations and the exchange of teachers, lecturers and students among the universities and schools and engineering associations; by developing rules of professional practice and codes of professional ethics; by contributing to closer technical relations among the American countries and by advancing the economic development of all American nations.

What it does: In addition to the initial meeting in Rio in 1949, UPADI has held three conventions at which subjects of interest on engineering education, standards, code of ethics, engineering phases of industrial and economic development, and others have been discussed. A copy of the Professional Code of Ethics may be obtained from Engineers Joint Council. (Unofficially and from the viewpoint of the United States, one of the objectives in connection with hemispheric solidarity is to keep the American nations looking to each other—rather than to Europe—for standards, specifications and engineering guidance in general. Also to increase the circulation of engineering periodicals in the American nations.)

Convention: The next Convention of UPADI will be held in Mexico City during 1956. James M. Todd, a past President of ASME, is President of UPADI Fund, Inc., and Vice-President of UPADI.

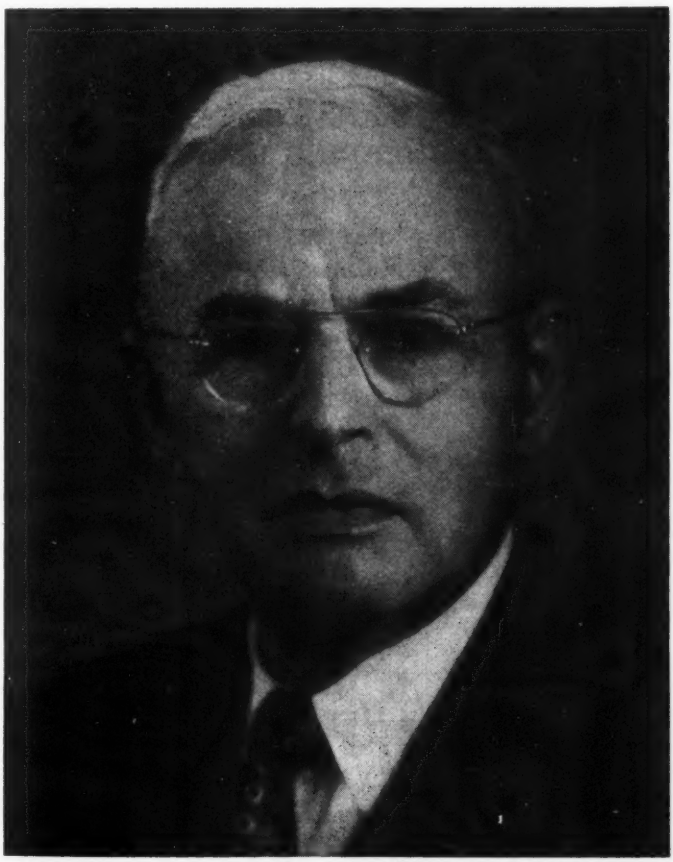
The American Rocket Society has joined **Northwestern University** in establishing a series of symposia in **Gas Dynamics.** The first symposium will be held on August 22–24, 1955 and its theme will be Aerothermochemistry. Papers to be presented will deal with 1) laminar flames; 2) turbulent combustion; 3) combustion instability; 4) ignition and the mechanics of sprays. Paper abstracts of about 300 words will be accepted until April 15, 1955 and the complete papers should be submitted by June 15, 1955.

Paper abstracts and correspondence concerning the Symposium should be sent to:

Gas Dynamics Symposium
Department of Mechanical Engineering
Northwestern University
Evanston, Illinois

The James H. McGraw Award in Technical Institute Education

To ARTHUR C. HARPER, *scholar, author, teacher, and administrator, for his outstanding contributions to technical institute education; for the stimulus he gave to young men who were his students during his distinguished career as educator; for his original developmental work in the organization and administration of technical institute curriculums at Pratt Institute and at the Wyomissing Poly-*



ARTHUR C. HARPER

technic Institute; for his creative writing as coauthor of the textbooks Kinematics and Kinetics of Machinery *and* Strength of Materials; *for his work in founding the American Apprenticeship Round Table and in the development of that organization's educational program; for his willing and energetic participation in the activities of professional societies in the field of technical education, this fifth annual James H. McGraw Award in Technical Institute Education is presented.*

The James H. McGraw Award in Technical Institute Education is an annual award of $500 for outstanding contributions to this field of education. The award is administered by the Technical Institute Division of the American Society for Engineering Education and is sponsored by the McGraw-Hill Book Company, Inc.

ENGINEERING ECONOMY COMMITTEE

AN EVALUATION OF ANALYTICAL TECHNIQUES OF ENGINEERING ECONOMY

PAPERS
Presented at
Engineering Economy Summer School

and

Annual Meeting
of
American Society for Engineering Education

June 12–18, 1954

University of Illinois
Urbana, Ill.

Price $1.50

May be secured from:

ARTHUR LESSER, JR.
STEVENS INSTITUTE OF TECHNOLOGY
Hoboken, New Jersey

The Teaching of Engineering Ethics*

By M. D. COOPER

Director, Mining Engineering Education, National Coal Association, Pittsburgh, Pa.

In order to obtain first-hand information in regard to teaching engineering ethics, the catalogues of 12 colleges and universities were examined. These were chosen because of the fact that those institutions have been visited by the Vocational Training and Education Committee of the National Coal Association. The Committee made the visits for the purpose of hearing informal reports by members of the faculties on their respective courses. Because these meetings have been pleasant and informative, the members of the Committee find themselves in a position to act as liaison officers between the mining industry and the educational institutions; and, for that reason, expect to continue the visits at the rate of two or three a year. It must be pointed out that the curricula were those in mining engineering as they were of primary interest to the members of the Committee; but, generally, freshman year was common to all branches of instruction in engineering and, in some cases, the same practice was followed through the sophomore year.

Mining is closely related to chemical, civil, electrical, mechanical, and metallurgical engineering. Therefore, it seems reasonable to choose it to represent the others. Among the 12 colleges and universities, there were 3 offering curricula in 5 years; and 9 in 4 years.

"Ethics" as a separate course was not listed in any of the catalogues, although "Religion" was noted in one where it was offered throughout Sophomore Year as a 3-hour recitation and lecture course. In the first term as "Religion 1," it is entitled, "The Life and Teachings of Jesus Christ"; and, is a survey course of the life and teachings as presented in the four gospels with application of the teachings to modern life. In the second term, "Religion 2" is called "The Beginnings of Christianity"; and is a study of the origin, founding, and early expansion of the Christian Church as recorded in the Books of Acts and the New Testament writings. Emphasis is put upon the basic doctrines of Christianity.

The Meaning and Value of Ethics

"Ethics" may be considered as a study of morals. Sometimes it is referred to as the science of moral duty, or of ideal human character. Since it is a science, it seems to have a clear relationship to engineering.

Engineering deals with materials, power, and human beings for the benefit of all mankind. Materials in the form of equipment and fuels; power, as electricity, steam, compressed air, gasoline or diesel engines; and human beings who design, operate, and maintain the means of providing necessities to progress are essential elements of engineering.

Accuracy is one of the virtues of engineering. It is taken for granted. Not so easily recognized in the development of engineering is beauty, yet the trend is all in that direction in the design of structures and machinery, and even their surroundings. Because many early engineering installations were temporary, not much attention was paid to appearances. As more permanent works developed, beauty was given greater consideration.

* Presented at the Mineral Engineering Division, ASEE, meeting, University of Illinois, June 15, 1954.

Human relations, another part of good engineering—often neglected in the past, are increasingly important. The relations of employer and employee; industry and community; competition; air and stream pollution; transportation; and many other factors of modern living are closely involved with the science of ethics.

Teaching Ethics

Since it is apparent that there is a good deal of ethics associated with engineering, the question arises: Shall it be taught as a separate course? Immediately, the usual cry goes up that engineering curricula are already overloaded. Is that true? An examination of the catalogues previously mentioned reveals that 10 out of 12 provide for technical or non-technical electives. Many have courses in business organization, introduction to mining, freshman engineering lectures, mine administration, seminars, professional problems, and technical society meetings during which at least some of the major elements of "Ethics" could be presented. A single lecture period devoted to a discussion of the "Faith of the Engineer" would be time well spent. A small part is worth much if it can be impressed on the minds and in the hearts of engineering students: "To my fellows, I pledge, in the same full measure I ask of them, integrity and fair dealing, tolerance and respect, and devotion to the standards and dignity of our profession."

Even in the technical courses, there are certain parts where the ethical considerations need special emphasis. Mining is a field in which this applies, perhaps less now than formerly. T. A. Rickard in his book, "A History of American Mining," commenting on the Comstock Lode, says: "On the whole, looking back at the record of the Comstock, we may conclude fairly that notwithstanding the mechanical skill of the constructing engineers at Virginia City, the Lode did more harm than good to mining, because it accentuated the gambling phase and subordinated the industrial function in its feverish operation."

It appears then that there is opportunity for a brief course in ethics, either as an elective or as a part of a professional or introductory course.

Value of Ethics to the Professional Engineer

The reputation of the engineer is founded on ethics as he is judged not only by his technical knowledge but just as much by his moral ideals. Herbert Hoover in his "Principles of Mining" writes: "Engineering sense is that fine blend of honesty, ingenuity, and intuition which is a mental endowment apart from knowledge and experience. Its possession is the test of the real engineer. It distinguishes engineering as a profession from engineering as a trade. It is this sense that elevates the possessor to the profession which is, of all others, the most difficult and the most comprehensive."

Engineers as citizens in the community are in a position to add to the welfare of their fellows by participation in worthy causes. In fact, they are so well prepared for such activities that there is a responsibility resting upon them.

Throughout the nation, the engineers are entrusted with great projects, many of them covering wide areas in two or more states. The ethics of their profession are especially prominent in such works.

George Herbert Palmer in his book, "The Field of Ethics," concludes that "Ethics is certainly the study of how life may be full and rich, and not, as is often imagined, how it may be restrained and meagre."

Conclusion

There is evident need of instruction in ethics for engineers. In spite of full curricula, time is available in electives or in connection with technical or non-technical courses, or in seminars for at least an outline of the subject. By precept or example, students of engineering may be made to understand that their fellow men respect good behavior.

Methods Used in the Presentation of Manufacturing Process Courses *

By M. L. BEGEMAN AND B. H. AMSTEAD [1]

In the engineering profession changes are constantly taking place, since industry, spurred on by necessity and aided by intensive research, is ever developing innumerable machines, processes, and materials. It is essential that engineers in training, particularly those who will work in industry, have a knowledge of the possibilities and limitations of these new developments. Also the economic aspects of both the processes and materials must be known if good design and low factory costs are to be obtained. Knowledge of how things should be done, what constitutes good workmanship, and the ability to apply engineering principles are important assets to the engineer.

Because of this rapid development and change, it is important that courses and curricula continue to be reviewed. Engineering education is not static and the training of engineers should reflect the progress and the trend in all new developments. However, in this discussion, we shall be limited to only one course in the curriculum, manufacturing processes, a course which should give the engineering student a comprehensive picture of present day manufacturing and the various techniques which have been developed. While the course title includes all manufacturing, actually the courses normally cover only the manufacturing of metal products and other commonly used materials. These courses usually include instruction in metal casting, forging, heat treatment of metals, hot and cold working, welding, machining, measuring tools, and frequently additional processes such as the forming of plastics, powder metallurgy, and wood processing.

Course Objectives

In the training of engineers in the technical fundamentals of these important processes and tools, much is also learned about materials and engineering fundamentals. Our problem then is to devise the best method possible to present this material to the student. This includes such decisions as to methods of presentation, material that should be included, and what emphasis each process should be given. With this in mind, let us consider the objectives of such a course and then determine how these objectives can best be attained. They have been stated many ways, and it is obvious that all such courses do not aim for the same goal. Some of the objectives frequently given are as follows:

1. To train engineers in the technical fundamentals of important manufacturing processes, engineering materials, and in the modern machine tools necessary for processing these materials. Such an objective stresses knowledge of metal cutting principles and applications involved in the operation of machine tools. It emphasizes a need for knowledge of manufacturing methods so that a designer may function for economical manufacture or

* Presented at ASEE Mechanical Engineering Sumer School, Navy Pier, Chicago, June 21, 1954.

[1] M. L. Begeman is Professor of Mechanical Engineering and B. H. Amstead is Assistant Professor of Mechanical Engineering at The University of Texas, Austin, Texas.

a production engineer may be able to make proper equipment selections for a given job.

2. To give engineering students some practical applications of engineering principles; that is, a knowledge which emphasizes the need for integrating practice with theory. Technical information, with the knowledge as to how it is to be applied, is most valuable.

3. To train students to appreciate workers who must operate the many machines of industry. Experience is an excellent teacher as it brings about appreciation and lasting memory of the work accomplished. It develops in individuals a viewpoint which must be practiced by those who lead and supervise others.

4. To develop a sense of creativeness in the individual. It is not important that certain manual skills for making things be developed, but knowledge of how things are made is an incentive to work out problems and to be creative.

In looking over the various courses offered in engineering schools, it is obvious that ideas vary as to how these objectives should be accomplished. There is a variation in empahsis which is reflected in the type of course given, subject matter covered, and the method of presentation which is selected. Examples of this variation are indicated in courses which emphasize:

1. Machine tools, their use, operation, and limitations. This type of course emphasizes the machine or process and for what it can be used.

2. Theory of metal cutting, metal forming, machinability, cutting tool forces, etc. Such studies border on research and attempt to bring out how cutting and forming operations can best be done.

3. Processes and machines, but with little or no emphasis on operation. Such a trend may be followed if there is a lack of time or appropriate equipment.

4. Study of processes and machines as they affect the design of products.

5. Engineering materials, their properties, and how they may be changed in form.

6. Operation of machines and processes. This should not be emphasized to the extent that the training becomes vocational in nature.

It is not implied that a course follow only one of the trends listed. It is quite possible to include several or all of them in a course, even though one factor is emphasized more than the others. Emphasis should be placed upon that phase of the work which develops the desired objective.

Types of Courses

Courses offered in manufacturing processes can be classified either according to the material covered or according to the method of presentation. If we consider the first classification, we find there are two methods used. First, there are schools offering single courses which cover all phases of the subject. There has been some trend for this type of course because of the limited time available in an engineering curricula. In order to include new developments in engineering and at the same time more cultural training, many schools now offer all their shop work in one course. This is probably the best procedure to follow for such situations. Close coordination of all phases of the work is possible in such a plan.

Secondly, the work may be offered in several separate courses, each one covering but one phase of the work, as for example, metal castings. This is probably the way most manufacturing process courses started years ago. The outstanding advantage is that by allowing time for a number of separate courses, more material can be covered than under the one-course plan. Coordination of separate courses is sometimes difficult and there is tendency toward over-emphasis of certain phases of the work. However, by having more emphasis on manufacturing process courses, the student has a more comprehensive training and is bet-

ter prepared for work in industry. A modification of this second arrangement exists when two courses are offered, each one including several phases of the work. This is an expansion of the single-course arrangement and is desirable if sufficient time is available.

If courses are classified as to the method of presentation, there are several possibilities. In reviewing the methods followed at various institutions, there appears to be wide divergence of opinion as to how this work should be taught. Each method should be evaluated in terms of the course objective. According to method of presentation, the following course plans are in use:

1. Lecture course with no laboratory work. Courses are presented in this fashion where there is no equipment available, in cooperative courses where practical experience is gained in various shops, and in cases where it is felt that most students have already had laboratory training in technical high schools or industries. In the conduct of these courses there is probably the feeling that the student is adequately trained in the knowledge of machines and processes by lecture and classroom work rather than by laboratory work. It is necessary to make considerable use of visual aids, since the student has no access to actual equipment. All of the objectives cited earlier in this discussion cannot be attained by this method of presentation, which no doubt accounts for the fact that it is not widely used. It was the experience of the authors in using this plan for training Navy students during the war that it was not satisfactory to either the students or instructor.

2. Lecture course with inspection trip period each week. An improvement of the lecture course plan is made when opportunity is provided for the students to visit plants and see equipment in action. An example of such an arrangement is a course having two lectures a week and one three-hour inspection trip period. The inspection trip is coordinated with the subject matter being studied in the text and students are usually asked to prepare a report of the trip. This plan of study requires close proximity to a highly industrialized area having many types of industries.

3. All laboratory work with occasional time out for lecture and demonstration. The first two methods described stress lecture and classroom work while this method places the emphasis on work in the laboratory. While there is no classroom lecture or discussion period provided, there must be occasional portions of the laboratory period set aside for demonstrations, lectures, or the use of visual aids. This method of presentation is used to get more contact hours with the students and can result in requiring more of the students for their credit than by other methods. Usually when this type of a course is given, outside assignments are not made and the value of text study is lost. There is also some tendency in these courses to stress operations rather than advantages and limitations of the process and the principles involved.

4. Combination of lecture and laboratory work. This is a compromise between the types of presentation mentioned above and is an attempt to combine their advantages. Such courses have provision for lecture, text assignments, actual laboratory experiments or machine operation and demonstrations, all of which includes most of the teaching methods that are used. Most courses are patterned along this line, although there is much difference in the way schools use their laboratory time. This matter will be discussed in more detail under the type of projects used.

Laboratory as a Means of Instruction

In looking over the methods of presentation and evaluating them, we must certainly consider the advantages and limitations of laboratory as a means of instruction. It appears that there is hesitancy on the part of some schools in

accepting this means of instruction as suitable for a course in manufacturing processes. Some of the advantages are:

1. A greater interest in the course is developed when the student is able to see and operate various machines.

2. The student is brought into a shop atmosphere. Here he learns something of the viewpoint of an individual who operates machines day after day. This cannot be obtained from textbooks or lectures.

3. A better knowledge of the process is gained. Certainly there is more opportunity for the student to learn when facts and theory are supplemented by laboratory work. With this increased knowledge there is a better appreciation of industrial operations.

4. The student is given an experience which may assist him in determining his lifework—at least the more industrial experience he has, the earlier he can make such a decision.

5. The ability of a student to work more independently on research and creative problems is improved by reason of his knowledge of "how to make things."

Disadvantages which can be cited for laboratory type instruction include:

1. Laboratory instruction is time consuming for both students and instructors.

2. Laboratory equipment is expensive. This tends to limit class size and causes teaching costs to rise.

3. Laboratory work is thought by some to be vocational in nature. Whether or not this is true depends on how the course is conducted.

In summary, it appears that there is much to be gained by using laboratory techniques in conducting a course of this type. This fact is verified by the success of cooperative training programs where a student alternates between school and industry giving each about an equal amount of time. These programs indicate that their success is due largely to the shop and laboratory type experience given them during their time with industry.

Types of Projects Used

As previously stated, the success of any laboratory instruction depends upon the type of work which is assigned the students. Here again we see wide variation in this phase of the instruction—projects vary greatly as do their aims. A survey of a number of engineering colleges indicates the following type of projects in use:

1. Small projects, each attempting to illustrate the use of some machine or operation. Projects of this type can usually be completed in one period or less and include such things as making a screw, mandrel, gear, test specimens, parallel bar, C-clamp, etc. Projects should be selected which give the student operating experience on a wide variety of machines. Emphasis should be more on the quantity of projects completed rather than excellence or quality achieved. This project method used for many years still enjoys wide use. Its principal disadvantage is that the work may become somewhat vocational in nature if the instructor is not alert. Also it does not bring out the principle of interchangeable manufacture.

2. Special projects of a more complicated nature which are not repeated, such as the building of a small press, a dynamometer, a polishing stand or grinder, or special equipment needed for research. While there may be good interest developed in a project of this sort, it does have the disadvantage that the work to be done is not balanced. That is, the student may be forced to work most of his brief time on the same type of equipment. Again there is a tendency for skill to be emphasized rather than the knowledge of the equipment used and engineering principles involved.

3. Report type projects involving experiments on tool life, cutting tool forces, cutting speeds and feeds, or special ma-

chining operations. On projects of this sort nothing useful is produced as the machine is operated only to obtain certain data. Upon completion of the experiment computations must be made, possibly curves prepared, and the results or conclusions of the work set forth. This type of project is used more in upper level courses than at the freshman or sophomore levels. It is a method which gives the student some idea of a research approach and yet teaches him something of the capabilities of the machine. Report type projects require more planning and preliminary instruction and involve the grading of a report.

4. Production-type projects where all parts are made on a quantity production basis. The idea here is to simulate actual production methods as used in industry. Projects of this type which have come to the author's attention include a drill press, grinding stand, milling machine vise, table saw, sheet metal tools, and other similar projects. Here again it is necessary to do a great deal of planning ahead and preliminary work such as the preparation of prints, operation sheets, parts lists, and class schedules. In addition there are jigs, fixtures, and special tools to be designed and made. Much of this preliminary work can and should be done in the design and advanced tool engineering classes under the supervision of an instructor. Each machine should be properly tooled up for some required operations with appropriate class schedules and instructions worked out.

If the preliminary work is complete and well done, a student is able to do much more work and operate more machines than by any other project method. In addition to becoming familiar with the machines, the student also learns something of production methods and tooling as used in industry. If the project selected does not use all the equipment desired, other projects can be added. The value of interchangeability of parts is brought to the student's attention in the assembly operations.

Case Study of Instruction Using a Single Course

At The University of Texas a single semester course, meeting one lecture hour per week and two three-hour laboratory periods per week, is used to present manufacturing processes material to the mechanical engineering students. This is a three-credit hour course.

A textbook is used and the subjects covered are pattern work, metal casting, forging, hot and cold working, welding, measuring tools, metal machining, plastics, and powder metallurgy. The seventeen weeks of laboratory are divided into four fundamental instructional units. Approximately two weeks (12 clock hours) are devoted to pattern shop instruction, approximately three weeks (18 clock hours) to instruction in metal castings, approximately three weeks (18 clock hours) to welding instruction, and the remaining nine weeks (54 hours) to instruction in the machining of metals. In both the lecture and laboratory visual aids are used liberally.

All of the work in the laboratory this past year has been centered around a single project. The project is an eight-inch circular table saw which is equipped with tilting table and adjustable saw height features. Although the project has been used only two semesters and continuing revisions are necessary, approximately 100 table saws have been finished each semester.

In the short time devoted to pattern shop work, emphasis is placed on the making of match plate patterns. In the foundry the fundamentals of hand and machine molding, core making, and metal melting are practiced by the student. Emphasis is also placed on quantity production of aluminum castings, since in each table saw there are nine separate aluminum castings weighing approximately twenty pounds. For 100 saws approximately 2500 pounds of aluminum must be poured in the foundry each semester if allowance is made for gates, risers, and scrap. Aluminum is

melted by means of a coke furnace, a gas-fired furnace, and an induction furnace. Brass and cast iron are melted and poured at least once each semester to acquaint the student with the processes involved.

In the welding shop the students learn the fundamentals of gas and electric welding. Again no appreciable skill is obtained by the student; however, enough ability is usually absorbed by the student for him to be capable of doing the very simple welding necessary on the saw frame. One three-hour period of the welding laboratory is devoted to demonstrations of electric resistance welding, flash welding, brazing, torch cutting, silver soldering, aluminum welding, inert gas-shielded welding, and other specialized processes in the field.

The first period of machine shop instruction is devoted to the demonstration of basic machine tools such as the lathe, shaper, planer, and milling machine. Thereafter when a student arrives in the laboratory he goes to a group of drawers and selects one drawer which contains all the special tools and instructions for a given operation and directs the student to a specific work place. The student punches "in" on a time clock and indicates on the time card the part number and operation number of the job he is on. Most of the machines in the laboratory are set up for production runs on parts for the saw. Both written and instructional help is used to "break in" a student on a machine or process new to him.

A student does not necessarily change jobs each day, but may change once or twice during the period. The instructors mingle through the class and each time a student appears to have had sufficient time on a machine to be familiar with the processes and the fundamentals involved, he is moved to another job. In order to check on the diversification of experience of the student in the laboratory, an instructor need only refer to the student's time card.

In all there are approximately fifty different parts made in the laborato for this saw. The only parts which a purchased for the saw are the ball bea ings, the saw blade, and the miter hea It is hoped that within a very short ti the miter head can either be die cast cast in a shell mold in the foundry la oratory.

During the last week of each semest the students work on the saw assembl line. This training makes them awa of industry's problems in mass produc tion. It gives them the realization of th accuracy and quality of workmanshi necessary for interchangeable manufa ture. It is quite apparent that the espri de corp of the student is increased whe he is working on a project of this type The student can, if he desires, purcha a saw for the cost of the materials alone

There is considerable cooperation be tween various courses as a result of thi project. The machine design class furnish the drawings which are constantl being revised. The required and electiv courses in industrial management, plan layout, time study, quality control, ad vanced metal castings, etc., now have practical problem to which students ca devote their energies. The advantages o an arrangement of this kind are obviou since any theories that an instructor o student may wish to advance in any o these industrial type courses can be tried out in the laboratory and their value de termined. This method of presenting lab oratory instruction appears to incorporat all the salient features of laboratory in struction.

Present Practice in the Teaching of Manufacturing Processes

Possibly some trends in the teaching of manufacturing process courses ca best be studied by examining the pra tices of thirty-five engineering colleg selected at random. The following in formation was obtained from correspond ence and in some cases the data was in complete. The table is based on curricul in Mechanical Engineering, although i

was noted that the practice in Industrial Engineering curricula was quite similar.

Teaching Practice	Number of Schools
Method of Presentation	
No course given	1
Lecture instruction only	4
Laboratory instruction only (informal lecturers)	6
Lecture and laboratory	22
Lecture and demonstration	2
Type of Laboratory Work	
Small projects	18
Special (research type) projects	1
Reports (including inspection trips)	3
Production-type projects	8
No laboratory	4
Material Covered in	
Single semester course	9
Two semester course	15
Multiple courses (welding, casting, etc.)	10
Courses Taught by	
Industrial Engineering Department	6
Mechanical Engineering Department	22
Other	6
Classification of Student	
Freshman	1
Sophomore	20
Junior	4
Senior	1
Covered over several years	8
Credit Given	
Two hours	4
Three hours	7
Four hours	12
Five hours	4
Six hours	7

In studying the various course offerings of these schools, it should be noted that many of them have additional courses in the fundamentals of manufacturing processes other than those listed above. Such courses are provided for production options and electives for those interested in production work. The thirty-five selected schools in this survey constitute a representative and sufficiently large group to provide the following fairly accurate conclusions as to present practice and trends in the teaching of manufacturing process courses:

1. Practically all engineering schools give a basic course in this subject. The few that do not recognize a need for a knowledge of the subject, but differ as to how and when it should be obtained.

2. A combination of lecture and laboratory work is the usual method of presentation. In cases where laboratory work alone is scheduled, it should be noted that informal lectures and demonstrations are generally used to supplement the work.

3. In recent years there has been some trend towards a single course covering all phases of the subject; however, many schools are still spreading the work over two semesters. In the latter case foundry, pattern work, forging, hot and cold working, welding, and possibly other subjects are given in one semester, while the second semester deals principally with machine shop work and inspection. Multiple courses; that is, a series of courses, each on a single phase of shop work, require more time than most schools wish to allow and are considered difficult to coordinate.

4. Most courses are taught in the Mechanical Engineering Department.

5. Courses in manufacturing processes are predominantly scheduled in the sophomore year. This appears to be a desirable place in the curricula for the course to best help the student in his design work.

6. Most Mechanical Engineering curricula provide approximately four semester hours for this work.

7. There is a general feeling that this course should have close coordination with other required courses. Probably its greatest value is that it teaches the student how to design parts that can be made economically. Design work requires more than just stress calculations—materials must be selected, heat treatments specified so that desired properties are obtained, tolerances selected in line with

both functional requirements and the ability of the machine to produce them, and often the selection of the process itself.

The above survey emphasizes the fact that several methods of teaching a fundamental course in manufacturing processes are still being used. Although on each point tabulated there is one procedure followed by the majority of the schools, it cannot be concluded that that procedure is the best one. To make this decision we must continually review our objectives and see whether or not they are being accomplished. Are we training the student in the technical fundamentals of important manufacturing processes? Is the student learning and observing practical applications of engineering principles? Is he developing a sense of creativeness and gaining some appreciation of work accomplished?

These questions are all difficult to answer in a positive manner. The student's response to the course, his interest, and how he applies the information to his later courses all give some indication as to the answer. Likewise the instructor must sense whether or not he is doing the job he should and if he is getting the desired results. Certainly departments should periodically review their courses to see whether or not they reflect the progress which is constantly being made in the engineering field.

College Notes

The **University of Florida, North Carolina State College, Virginia Polytechnic Institute** and the **Southern Regional Education Board** are jointly sponsoring a series of cooperative summer sessions in statistics. The first of these cooperative graduate summer sessions was held during the summer of 1954 at Virginia Polytechnic Institute. At this session there were 89 students from 26 states and the District of Columbia, and from India, Finland, Canada, Australia, China, Hawaii and the Philippines. The following courses were offered: Engineering Statistics, Statistical Methods I, Statistical Theory I (Probability and Inference), Biostatistics, Quantitative Genetics, Rank Order Statistics, Multivariate Analysis, and Seminar on Recent Advances in Statistics. Classes ranged in size from 9 to 34, with an average of 20. The second session will be held at the University of Florida from June 20 to July 29, 1955. A session is scheduled to be held at North Carolina State College in 1956, and another at Virginia Polytechnic Institute in 1957.

In the News

Appointment of James M. Mitchell as Assistant to the Director of the **National Science Foundation** has been announced by Dr. Alan T. Waterman, Director. Mr. Mitchell's responsibilities will be largely concerned with the Foundation's program of fact-finding studies on scientific activities and manpower in government, industry, and universities.

A fund of $291,000 for grants to universities and colleges to help improve the teaching of science and mathematics was announced by the **Du Pont Company** as part of its $800,000 aid-to-education program for 1955–56.

THE T-SQUARE PAGE

CONTRIBUTIONS TO ENGINEERING EDUCATION
BY THE
DIVISION OF ENGINEERING DRAWING

T. T. AAKHUS, *Chairman*
University of Nebraska

HAROLD P. SKAMSER, *Secretary-Treasurer*
Michigan State College

WILLIAM E. STREET, *Vice Chairman*
A & M College of Texas

IRWIN WLADAVER, *Editor of*
the T-Square Page
New York University

Graphics and Differential Equations

By PROFESSOR STEVEN A. COONS

Assistant Professor of Graphics, Massachusetts Institute of Technology

The solution of ordinary differential equations by machine depends upon two very simple ideas; the use of integrators, and the use of feedback. Thus the mechanical hook-up for solution of the differential equation for a series circuit in electricity may be diagrammed:

$$L\frac{di}{dt} + Ri + \frac{1}{C}\int idt = e$$

or

$$\frac{di}{dt} = \frac{1}{L}\left(e - Ri - \frac{1}{C}\int idt\right)$$

Now the integrations involved may be performed graphically, and feedback simply means comparing the result with the original assumptions. Thus to solve a differential equation graphically we assume a graph for di/dt over a suitably small interval of time, Δt, and perform the indicated operations. The result is a graph of di/dt over the same interval which is different from the original assumption and is a closer approximation to the true function. If we repeat the circuit of the steps in the process, the successive graphs tend to consolidate, and eventually further excursions around the circuit fail to show any difference between the assumed di/dt and the di/dt

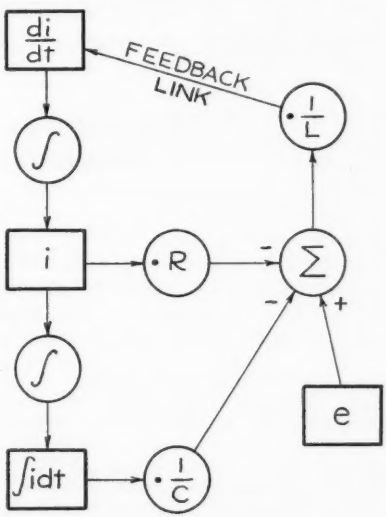


FIG. 1

fed back. Then over the interval we have a solution of the equation, and can proceed to the next Δt. It turns out that the successive trials converge rapidly, so that this is a practical method to use. But more than being merely a graphical device, it has value because it demonstrates in a tangible way the meaning of differential equations; one can actually see the solution generate itself, and one is more aware of the part played by the derivatives of various orders and their interaction.

In the present example, the voltage "e" may be any function of time that can be plotted; then the voltages in the various branches of the circuit appear as graphs which draw themselves almost automatically. Moreover, the diagramming of such an equation is precisely the step one would take in preparation for setting it up on a computer. Hence this graphical approach to differential equations is an educational tool which sheds light on their nature and their mechanical solution.

PROCEEDINGS OF THE THIRD NATIONAL SURVEYING–TEACHERS' CONFERENCE

August 3 to 8, 1952

Sponsored by

COMMITTEE 8—SURVEYING & MAPPING
CIVIL ENGINEERING DIVISION
THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

and

CIVIL ENGINEERING DEPARTMENT
UNIVERSITY OF ILLINOIS

Held at

Camp Rabideau
University of Illinois
Blackduck, Minnesota

Price $2.50

May be secured from:

SUMNER B. IRISH, *Editor*
SCHOOL OF ENGINEERING
Princeton University
Princeton, New Jersey

A Graduate Curriculum in Technical Writing

By STERLING P. OLMSTED

Head, Department of English, Rensselaer Polytechnic Institute

That there is a rapidly growing need for technical writers and editors hardly requires demonstration. This article is a report on an attempt to meet that need, now in experimental operation at Rensselaer Polytechnic Institute.

Mr. Christian K. Arnold, writing in the JOURNAL for November 1954, proposes an undergraduate curriculum which includes "basic training in the tools of both the editor and the scientist: composition, physics, mathematics, and chemistry as a bare minimum." The R.P.I. program seeks to accomplish somewhat different results by superimposing a graduate major in technical writing and editing on an undergraduate education in science or engineering.

Other solutions will undoubtedly be devised as the demand becomes more insistent. The field is a large and varied one, and it is still growing. At least 2000 periodicals are devoted to various fields of interest in industry and business, and another 1500 are published by industry itself. Many companies have technical writing departments whose job may range from the editing of engineering reports to the preparation of proposals and the writing of operation and maintenance manuals. According to one estimate, there are over 10,000 technical writers in the country today, but the boundary lines of the profession are so nebulous as to make all estimates highly conjectural. Technical writers are not only numerous; they are becoming profesionally conscious. Within the past year societies of technical writers have been organized in the New York, Boston, and Schenectady areas, and the head of one large technical writing group has even proposed a new term, "publications engineer," to describe those working in the field.[1]

Up to this time most of those who man this growing enterprise have been either scientists or engineers who have developed an interest in writing (or who have been drafted for writing and editing) or else English or journalism graduates with an interest in science. Apparently the biggest demand is for engineering graduates who can write. H. C. McDaniel and C. A. Scarlott, writing in the *Journal of College Placement*, assert that it is "essential that a technical editor have a formal engineering education." They add that "of 32 technical and trade magazines polled on this question, all but two required an engineering degree. These two preferred a B.A. in business administration to journalism."[2]

The R.P.I. program has been planned with this requirement in mind. The degree offered is a *Master of Science with a major in technical writing.* Candidates for this degree must hold bachelors' degrees in science or engineering. No English majors need apply. Students are required, furthermore, to continue their scientific or engineering work at the graduate level, either taking advanced

[1] R. Hamlett, "Technical Writing Grows into New Profession: Publications Engineering," *Proceedings of the I.R.E.*, October 1952.

[2] H. C. McDaniel and C. A. Scarlott, "Technical Writing Opportunities for Engineering Graduates," *Journal of College Placement*, May 1954.

courses in their undergraduate field or branching out into another field for which they are qualified. The advantages to the technical writer of broadening his scientific background are obvious.

The greater part of the program, however, is in writing, editing, and related subjects. The required writing courses which form the core of the program have been designed to furnish the student with balanced experience in composition. A year's course in writing and editing is handled essentially as a technical writing laboratory. Here, emphasis is placed on developing facility. Students gather material, write, edit, re-write, adapt their own and other men's material to new purposes and new readers, expand and condense—always under continually increasing pressure of rigid deadlines and exacting requirements in copyfitting.

Running parallel with this course are two other one-semester writing courses in which there is less pressure to produce and more emphasis on finished, polished work. In the first of these courses students concentrate on the development of a good prose style. They begin by examining the theory of language and the problems of style and organization, attacking the subject with the same scholarly rigor demanded of the English major in a traditional graduate school. They then go on to apply the theories which they have studied, producing articles on a variety of subjects. In the second course, *Writing for Publication,* students take the next step: they not only try to write finished articles, they also slant them toward particular journals and submit them for possible publication. The object of this course is not to turn out free-lance writers, but to give students oportunity to develop individual styles, on topics (technical and non-technical) in which they are interested.

Other Courses

The other courses in the technical writing major are related to this core in various ways. *Mechanics of Publishing,* for example, is designed to make students better writers by giving them some knowledge of the actual techniques by which material is reproduced and of the editorial organizations which are responsible for this work. The objective is not to turn potential technical writers into printers or bookbinders, but to help them understand the possibilities and limitations of the finished product for which they are writing and planning copy. Similarly, a one-credit-hour course, *Law for Writers,* is aimed not at producing an expert in the laws of copyright and of libel, but rather a writer who will avoid producing copy that an editor or lawyer would reject. An elective course in *Methods of Presentation* emphasizes the non-verbal techniques which are used so extensively in technical publications.

As a counterbalance to these specialized, practical courses, and to guard against the tendency to "journalese" inherent in *Writing and Editing,* students are required to take a term course in *Scientific Masterpieces,* which is intended to give them not only some understanding of the development of English prose style but also an acquaintance with the historical backgrounds of science and technology. The student who wishes to go more deeply into the background and implications of science may elect a course in the *Philosophy of Science,* while the man who wants to know more about the range of his profession may elect *Scientific Writing in America.* This last course has also been planned in the best traditions of the graduate seminar in English in so far as these traditions are applicable to this field. The student is asked to carry out an independent investigation of the history and methods of a particular publication, type of writing, or mode of presentation. Since this is an almost untouched field for scholarly investigation, the possibilities of original work are immense.

So far R.P.I. has not required a Master's thesis as part of the program

If it elects to do so in the future, it is probable that much of the spade work for such theses will be done in the course in *Scientific Writing in America*. At the moment it appears to those in charge of the program that the amount of research and writing assigned during the year makes a thesis requirement unnecessary.

It is perfectly clear that technical writers and editors can be developed through on-the-job training. After all, this is the way they have been developed in the past. Most professions were at one time in this position: they first trained practitioners by the apprentice system. As they came of age, however, they began to require academic instruction which would fit a man not just for work with one organization, or one particular kind of job, but would give him background, versatility, and a knowledge of the whole field. This the R.P.I. program in technical writing attempts to do. It has not, so far, been slanted exclusively either to the technical press or technical writing in industry. Experience may show that such slanting is useful. It may also show that for some kinds of technical writing jobs, an undergraduate program such as that suggested by Mr. Arnold is the ideal preparation. At the moment the R.P.I. program is based on the assumption that a full undergraduate engineering education, or an equivalent education in science, is a prerequisite to a career in technical writing.

College Notes

An 8-week summer program of advanced study in highway engineering, open to instructors in engineering colleges, will be held at the **University of California**, Berkeley, beginning June 20, 1955, with the cooperation of the Institute of Transportation and Traffic Engineering. Twenty grants-in-aid of $650 each are available to make practicable the enrollment of instructors from throughout the United States. This financial assistance has been made possible by a grant from the Automotive Safety Foundation.

Northeastern University will break ground next June for the construction of a $1,500,000 Classroom-Laboratory Building. Pres. Carl S. Ell has announced that the Corporation had sanctioned the four story, 40 classroom structure to be completed by June 1956 for use by students by the fall of 1956.

A new research grant of almost a quarter of a million dollars will enable the **University of Pittsburgh** to continue its long-time contributions to the efficiency of the U. S. Navy's aviation ordnance equipment. Dr. G. R. Fitterer, dean of the Schools of Engineering and Mines at Pitt, announced that the U. S. Navy Bureau of Aeronautics has granted the schools $225,000 for a period of two years to study aviation ordnance equipment.

A clearing house for the Nation's military research and development in the field of electronic parts has been established by the Department of Defense at the **University of Pennsylvania.** It is the Secretariat of the Defense Department's Advisory Group on Electronic Parts. It is staffed and operated by the University's Institute for Cooperative Research, under Government contract.

The establishment of a professorship in electrical engineering at **Columbia University** through a grant from the General Electric Company was announced by Dr. Grayson Kirk, president of the University. The professorship will be used for teaching and research in the fundamentals of generating, handling and processing energy.

Engineering Economy and Operations Research*

By L. G. MITTEN

Assistant Professor of Industrial Engineering, The Ohio State University

In considering the relationship between Engineering Economy and Operations Research, we can compare them on the basis of

1. Purpose,
2. Methodology, and
3. Techniques.

I will undertake a definition of purposes and an analysis of the general problem considered by both disciplines.

In very general terms, I think it could be agreed that Engineering Economy and Operations Research have a common purpose or function; to provide a basis for executive decisions. Since many techniques are concerned with decision making, some of the generalized facts of decision theory should provide an interesting framework within which to compare and contrast the two methods.

The first aspect of decision making which we shall consider is the decision situation, i.e., the kind of situation which calls for the making of a decision. The decision situation may be characterized by the following conditions:

1. There is a purpose or objective which is desired to achieve,
2. Some action is required in order to achieve the objective,
3. There is a set of alternative actions by which the objectives might possibly be achieved, and
4. There are, in some sense, conflicting elements among the courses of action which might be pursued.

An important difference between engineering economy and operations research is to be found in the type of decision situations falling within each of their provinces. Engineering economy, almost by definition, is concerned with those situations in which the objectives and the alternative courses of action entail both engineering and economic considerations. Thus, if from the set of all decision problems we select the two subsets of engineering problems and economic problems, the intersection of these two subsets represents the set of problems to which the engineering economy techniques are primarily applicable.

Operations research deals with a somewhat different group of decision problems, namely, the sub-set of decisions concerning operations. Now I am not at all sure that I understand precisely what is encompassed by or excluded from the field of "operations" (any more than I am sure that I understand the precise limitations on the field of engineering). However, some notion of the meaning of the concept may be obtained from the folowing definition; an operation is a system of interrelated machines and/or men and/or materials. Despite its inadequacies, the above definition does give us some crude basis for comparing the sets of decision problems treated by engineering economy and operations research.

It is clear that a large number, but not all, engineering economy problems may also be considered as operations research problems, and, in addition, operations research problems encompass a vast area not included within the domain of engi-

* A paper presented before the Engineering Economy Summer School of the American Society for Engineering Education, June 13, 1954, at the University of Illinois.

neering economy. Thus, while both techniques deal with decision problems and while the two fields overlap considerably, I feel that we must concede that the scope of problems considered by operations research is very much broader than in the case of engineering economy.

In addition to differences in the type of problem considered, operations research and engineering economy differ significantly in some aspects of problem solving procedures. For our purposes we may conceive of the "decision procedure" as consisting of

1. Model construction,
2. Criterion definition,
3. Choice, and
4. Action.

Model Construction

Most (if not all) of man's contacts with reality are accomplished through a series of symbolic transformations. This is true even on the most primitive level such as perception where the external stimulus is transformed by the receptor organ into an electrical impulse transmitted by the nervous system to its destination. The electrical impulse is, in a very real sense, a symbolic representation of the initial stimulus, i.e., it is a model which represents the initial stimulus. At the much more sophisticated level of decision making symbolic representation and model construction play a crucial role. The models used in various decision making methods may differ in a number of ways; they may range from a highly formalized symbolization (such as mathematics) to constructs so vague and tenuous that they are incapable of being formulated in even verbal terms. Models also differ considerably in the degree of isomorphism existing between a model and the situation being described. By way of clarification of the preceding statement we need merely point out that all model construction is an abstracitve process (i.e., from among the elements and relationships existing in the real situation only those which are considered to be relevant to the problem are abstracted from the situation, symbolized, and assigned a role in the model). If and assigned a role in the model) and if too few elements and relationships in the situation are selected for symbolization and inclusion in the model, or if the symbolization is inadequate for an accurate portrayal of the nature of the element or relationship, then the resulting model will not represent the situation with sufficient precision.

The models used by engineering economy and operations research are similar in that they are, in general, quite highly formalized and it is this fact which differentiates them from the cruder forms of decision making by hunch or guesswork. There are, however, some extremely important differences between the models used by these two disciplines. In the first place, the approach made by the engineering economist and the operations researcher to the process of model construction are quite different. Model construction is a conscious process for the operations researcher; the word model is an important part of his working vocabulary and he thinks in terms of the "diffusion model," "linear programming model," "queuing model," etc.. He *knows* that he is constructing models and he has received considerable training and great skill in this art. On the other hand, although the engineering economist uses models describing micro economic-engineering situations, he is not, in general, aware of the fact that he is using a model and is not likely to give too close attention to the formal steps in its construction. In fact, we might say that the engineering economist selects an "off the shelf model" rather than assembling his own. We might go even a step further and state that the activity of most practitioners of engineering economy merely determine the values of the set of parameters for one of three or four highly standardized models and that the process of model construction or even

model selection is generally outside his realm (at least with respect to economic models).

With the above facts in mind, it is readily understandable that the models employed by operations research workers are considerably more sophisticated and, I believe, more accurate than those of the engineering economist. No small part of the effectiveness of operations research workers in the field of model construction is due to the "team approach" which characterizes most of operations research work. Within the team will be found a wide variety of disciplines, each discipline encompassing, in general, many different analytic tools which form the raw material for model construction. Thus, in addition to the standard engineering techniques, operations research makes extensive use of probability theory, the theory of stochastic processes, programming theory, calculus of variations, etc. As a consequence, the operations research worker is able to construct adequate models of situations whose complexity would baffle the engineering economist. Until the engineering economist becomes a much more conscious model constructer, and until he masters a much wider variety of analytic techniques (including those from the fields of the social sciences as well as the physical sciences and mathematics), he will not be nearly so effective as the operations research worker in performing his basic function, namely, providing a basis for executive decisions.

Criterion Measures

Another important aspect of the decision procedure is the definition of the criterion of choice or the measure of value or of merit, as it is sometimes called. In the case of engineering economy, the measure of merit is almost always defined in terms of cost, profit, and/or percent return on investment; it is the fixed criterion in economy studies, unquestioned by almost all engineering economists. In operations research, however, the definition of an appropriate measure of merit usually poses a very large problem which is consciously considered, weighed, and discussed. As witness of the fact that very serious attention is given by the operations researcher to the problem of criterion measures, it is interesting to note that a considerable amount of space has been devoted in the last two issues of the *Journal of the Operations Research Society of America* to the problem of value theory.

Thus, we find that the attention given to the problem of criterion measures is one of the characteristics which differentiates operations research from engineering economy—the engineering economist taking the criterion measure as given and unquestioned, while the operations research worker gives careful attention to the definition of a criterion measure which will be appropriate for the problem under consideration. As a consequence of this fact we find that operations research is able to give adequate solutions to a whole set of problems which the techniques of engineering economy cannot handle. In addition, among those problems to which both techniques are applicable we very often find that the solution obtained by the operations research worker is superior to that of the engineering economist because of the greater attention given by the former to the problem of criterion measures and because of his greater flexibility in dealing with the problem of value in general.

Let us review briefly the conclusions drawn from the preceding analysis. First, we find that both engineering economy and operations research have the same general purpose—to provide a basis for executive decisions—but that the problem area encompassed by operations research is considerably broader than that of engineering economy, and, in fact, the former includes a great deal of the area covered by the latter. Second, it is seen that operations research workers are generally much more adept at the construction of models of the decision situation than are engineering economists, and that their

models tend to be more sophisticated, more adaptable, and to provide a better representation of the situation under consideration. Finally, we note that the operations research worker is much more acutely aware of the criterion problem than is the engineering economist, and that as a result he is able to tackle a wider variety of problems and come up with generally more adequate solutions.

There is another factor which we have not yet considered, however,—the relative economy of the two methods. Operations research is an expensive undertaking, some current estimates indicating that it costs approximately $20,000 per year in direct and indirect costs to support one operations research worker. For engineering economists, my guess would be that the cost is, on the average, considerably less. Thus, for the vast majority of more or less routine decision problems that arise in the course of industrial operations, it would appear that engineering economy is an adequate and economic tool; it is only in those problems of considerable complexity, or those where refined methods might be expected to yield large savings, or in those cases where engineering economy techniques are inapplicable that operations research can be economically justified.

Conclusion

In conclusion, I would like to state my personal opinion that operations research is the best thing that ever happened to engineering economy. There is no question but that new techniques are and will be developed in the field of operations research which can be learned and used by the engineering economist; in addition, it is imposible to estimate the tremendous value to engineering economy of the stimulating effects produced by the great creative effort going into a friendly competitor such as operations research.

College Notes

The **University of Michigan**, College of Engineering, has announced two Intensive Courses in Automatic Control. The first is scheduled for June 13 to 18 inclusive, and the second for June 20 to 22, 1955, inclusive. The courses are intended for engineers who find it necessary or who wish to obtain a basic understanding of the field, but who cannot spare more than a few days for this purpose. The aim of the courses is to make it easier to learn by a coherent presentation of the fundamentals of modern automatic control and by providing a comprehensive set of notes to serve as a framework for further study.

April 15 is the closing date for registration. Further information may be obtained by writing to Professor L. L. Rauch, room 1521, East Engineering Building, University of Michigan, Ann Arbor, Michigan.

Dr. Robert A. Ramey, Jr., manager of the Magnetic Development Section of the Materials Engineering Department of the Westinghouse Electric Corporation (Pittsburgh), has been appointed Visiting Webster Professor of Electrical Engineering at **MIT** for the second semester of the current academic year.

Minutes of Executive Board

A meeting of the Executive Board of ASEE was held at Northwestern University, Evanston, Illinois on Monday, December 13, 1954 at 10:15 A.M. Those present included: N. W. Dougherty, *President;* W. L. Everitt, B. R. Teare, Jr., H. K. Work, *Vice Presidents;* C. W. Farnham, *Treasurer;* A. B. Bronwell, *Secretary.*

Appointment of the New Secretary

The Executive Board reviewed correspondence regarding all of the proposed candidates for the new Secretary to succeed Professor Bronwell, who is resigning to accept the position as President of Worcester Polytechnic Institute. Dean W. L. Everitt absented himself during the discussion and voting on the new Secretary, since one of the candidates under consideration was from the University of Illinois. President Dougherty and Professor Bronwell reported on several visitations to college campuses to interview candidates and examine facilities. A number of the letters of recommendation specifically requested that the Society headquarters remain in the Middle West, since this is near the geographical center of ASEE membership.

After considerable deliberation the Board voted to invite Professor W. Leighton Collins of the University of Illinois to take the position of Secretary of ASEE. The University of Illinois has offered to provide adequate space for the Society headquarters. It was recommended that the new office at the University of Illinois be set up about February 1.

The Executive Board expressed the hope that Marion Strohm would continue as the Executive Office Secretary and voted her a salary increase. The Board also voted to pay her room, meals, and travel expenses in connection with setting up the new office. It was decided to continue Professor Watson as Editor of the JOURNAL OF ENGINEERING EDUCATION throughout the current school year. The Board believed that it would be desirable to locate the Editor and Secretary in the same office so that they can exchange viewpoints on Society operations and also interchange secretarial assistance. It was suggested, therefore, that the editorship of the JOURNAL be moved to the University of Illinois as soon after June 30 as is convenient with the new Secretary.

Professor Bronwell stated that he would be glad to work with Professor Collins in effecting a smooth transition and will be available for consultation on ASEE problems. The Commencement Exercises at Worcester Polytechnic Institute occur on Sunday preceding the Annual Meeting; hence he may be delayed in arriving at the Annual Meeting. He further stated that the Society headquarters office has been preparing a Procedures Manual for the past five years, listing all the recurring responsibilities in the ASEE office. This will be helpful to the new Secretary in looking ahead and planning the Society operations.

Announcement Regarding the New Secretary

The Executive Board requested that Professor Lisle Rose prepare a publicity statement for publication in the Yearbook issue of the JOURNAL OF ENGINEERING EDUCATION, together with a photograph of the new Secretary. It was also suggested that this announcement be sent to other technical journals.

Resolution of Appreciation to Northwestern University

The Executive Board voted unanimously to send Northwestern University a

resolution of appreciation for space and facilities provided for the Society and also for the use of the Secretary's time.

IAESTE

The Secretary reviewed the recommendation of Mr. Boring that ASEE participate in the IAESTE program. This provides for an exchange of foreign students during the summer months for work experience. The advisability of participating in the IAESTE program was discussed as compared with that of attempting to provide job experience for foreign students who are already in this country. The Board suggested that a meeting might be arranged between Mr. Boring and members of the ECAC International Relations Committee to discuss these various proposals.

Graduate Study Project

The Executive Board reviewed the proposal as submitted by the Ad Hoc Committee studying the Graduate Study Project. The Board recommended that the Committee continue its investigation and prepare a specific proposal of topics to be studied and methods of achieving the results. In regard to finances, the Board recommended that the Ad Hoc Committee consider the financial needs of the project as a whole, rather than merely the needs of the first year of operation, since it is felt that a single appeal to industry would be much more favorably received than multiple appeals.

Humanistic Social Research Project

The Executive Board voted approval of the contract extending Dr. Gullette's services as director of the Humanistic Social Project on a part-time basis for another six months from January 1 through July 1, 1955.

Suggestion for a New Executive Board Member

A suggestion of the Secretary that the General Council be invited to elect a professorial member of the Executive Board from among their ranks was discussed. The purpose of this suggestion is to provide for a professorial member of the Executive Board, without at the same time placing roadblocks in the way of engineering deans who might be elected to the Board through the normal channels of officer election. This plan could go into effect without Constitutional amendment, although if adopted, it might be desirable to regularize it in the future by a Constitutional amendment in order to give the additional member of the Board vice presidential status.

The proposal suggested that the new vice president be given a certain area of responsibility in connection with the operation of committees of the ASEE. At present, the vice president in charge of Divisions and Committees has 35 different Divisions and Committees to supervise. This is such a large group that the vice president seldom attempts to maintain personal contact with more than a few of the Divisions and Committees within his area of operation. Therefore, a sub-division of work here might be desirable. The cost to the Society would be the travel expense of the new Board member to meetings of the Executive Board, which would amount to about $800 per year. It is felt that this is a small expense as compared with the advantages of having a member of the Executive Board with professorial rank.

The Board voted to send this suggestion to members of the General Council for their review.

Report of the Financial Policy Committee

A report of the Financial Policy Committee, recommending that the ASEE make additional investments in savings accounts, even though the money might have to be drawn out during certain months of the year when the Society cash account reaches its low ebb, was discussed. It was decided to table this matter for further consideration of the Ex-

ecutive Board after the new secretarial office is set up.

EJC Constitutional Amendments

The Executive Board reviewed the proposed amendment to the EJC Constitution and recommended favorable consideration, but requested that they be sent to the General Council for official vote.

ASEE Summer School

The Executive Board voted approval of two summer schools, one to be sponsored by the English Division and the other to be sponsored by the Chemical Engineering Division.

NSPE Affiliation with ECPD

A request from ECPD that the Society vote on NSPE becoming a constituent member of ECPD was favorably voted.

Authorization of Purchase of Furniture

The Executive Board voted to appropriate $1500 of the special projects reserve for the purchase of additional office furniture so that the Society will have its own office furniture, rather than relying on the host institution.

Travel Expense of Professor Bronwell

The Executive Board voted to authorize travel expenses for Professor Bronwell on official ASEE business during the transition period in order that he can work effectively with Professor Collins in making a smooth transition to the Secretary's office.

Statement of Professor Bronwell

Professor Bronwell expressed his grateful appreciation for the excellent cooperation he has received from the officers and membership of ASEE during his term as Secretary. The Society operations have increased substantially in scope and significance and the Society has been able to enlist the active support of the engineering colleges in its projects. This has been highly instrumental in cultivating an open-minded and inquiring attitude and in affecting implementation of its ideas.

Respectfully submitted,
ARTHUR BRONWELL,
Secretary

Sections and Branches

The **National Capital Area Section** of the ASEE held its first meeting for the year 1954–1955 at McMahon Hall Auditorium of the Catholic University of America on October 5, 1954, with Chairman Michalowicz presiding. During the short business session, it was announced that the principal theme for this year would be University-Industry Relations, and that the Winter Meeting would be held at the University of Maryland on February 1, 1955.

Dr. Henry H. Armsby, section representative to the General Council, made a complete report of the Annual Meeting in June, 1955. Among many items may be mentioned: (1) the change in dues; (2) adoption of a canon of ethics; and (3) award of honorable mention to Professor Adams, winner of our section's YET paper contest.

The principal speaker was Dr. Thomas J. Killian who sketched the development of the cooperative college movement from its inception in 1916 to the present time with a total enrollment of approximately 13,200 students.

New Members

ANDERSEN, JOHN R., Irrigation Specialist in Civil Engineering, South Dakota State College, Brookings, South Dakota. E. E. Johnson, W. H. Gamble.

ARNOLD, FRANK R., Acting Assistant Professor of Mechanical Engineering, Stanford University, Stanford, Calif. B. M. Green, W. M. Kays.

BAGGARLY, STEWART, Assistant Professor of Mechanical Engineering, Louisiana Polytechnic Institute, Ruston, La. L. R. Daniel, Jr., J. G. Chumley.

BAKER, MARGARET R., Special Instructor in Engineering Drawing, University of Texas, Austin, Tex. J. Lenhart, N. C. McGuire.

BENEDICT, NORMAN V., Instructor in Industrial Technology, Calumet Center of Purdue University, Hammond, Ind. M. E. Gyte, P. T. Meier.

BERGSTRESER, NEIL E., Assistant Professor of Civil Engineering, South Dakota State College, Brookings, So. Dak. E. E. Johnson, L. L. Amidon.

BERRY, FRANCIS R., JR., Assistant Professor of Engineering Design, University of California, Berkeley, Calif. J. Frisch, C. F. Garland.

BILLINGSLEY, JOHN G. S., Associate Professor of Mechanical Engineering, Norwich University, Northfield, Vermont. C. A. Renfrew, W. D. Emerson.

BORST, LYLE B., Chairman of Physics Department, New York University, New York, N. Y. Y. Beers, T. Saville.

DAY, JAMES A., Assistant Professor of Engineering Drawing, Wayne University, Detroit, Mich. R. W. Grant, H. P. Nelson.

DERKS, RICHARD J., Assistant Professor of Mechanical Engineering, University of Notre Dame, Notre Dame, Ind. C. C. Stevason, C. R. Egry.

DOUGLAS, DONALD C., Assistant Professor of Engineering Drawing, University of Michigan, Ann Arbor, Mich. F. H. Smith, R. S. Heppinstall.

FAGE, JOHN H., Instructor in Engineering, Pittsburgh Technical Institute, Pittsburgh, Pa. R. C. Gorham, J. R. Jackson.

FATOUT, PAUL, Professor of English, Purdue University, Lafayette, Ind. H. B. Knoll, G. E. Lommel.

FIREY, JOSEPH C., Assistant Professor of Mechanical Engineering, University of Washington, Seattle, Wash. P. L. Balise, J. B. Morrison.

FISK, GARRY L., Assistant Professor of Civil Engineering, South Dakota State College, Brookings, So. Dak. E. E. Johnson, W. H. Gamble.

FRYBERGER, E. L., Assistant Professor of Electrical Engineering, Valparaiso University, Valparaiso, Ind. H. C. Hesse, C. E. Peller.

FRYXELL, BURTON L., Head of Language Department, Michigan College of Mining and Technology, Houghton, Mich. J. M. Harrington, H. B. Anderson.

GRAFFIUS, PAUL H., Engineering Personnel Representative, Lockheed Aircraft Corporation, Marietta, Ga. R. L. Sweigert, B. W. Boguslavsky.

HAUSRATH, A. H., III, Assistant Professor of Engineering, Research Laboratory, Pennsylvania State University, State College, Pa. G. Murphy, W. L. Collins.

HAWK, MINOR C., Assistant Professor of Mechanical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. D. W. Ver Planck, J. W. Graham.

HEARTZ, FREDERICK R., Assistant Professor of Civil Engineering, South Dakota State College, Brookings, So. Dak. E. E. Johnson, W. H. Gamble.

HEMMERT, RAYMOND A., Assistant Professor of Mechanical Engineering, Tri-State College, Angola, Ind. J. C. Humphries, R. A. Hockey.

HINRICHSEN, JOHN J. L., Professor and Head of Mathematics Department, Iowa State College, Ames, Iowa. H. J. Gilkey, H. M. Black.

HOLCOMB, WALTER W., Instructor in Mechanical Engineering, Tri-State College, Angola, Ind. J. C. Humphries, P. A. Nurnberger.

HORAK, GEORGE C., Assistant Professor of Mining and Metallurgy, Lafayette Col-

lege, Easton, Pa. C. N. Truax, Jr., L. D. Clark.

HOUGHTON, JAMES E., Instructor in Engineering Drawing, University of Notre Dame, Notre Dame, Ind. L. Daniel, H. P. Ackert.

ITO, SEIWA, Assistant Professor of Engineering, Hokkaido Gakugei University, Iwamizawa Br., Iwamizawa, Hokkaido, Japan. T. Onodera, T. Watanabe.

KEHO, CLIFF H., Assistant Professor of Civil Engineering, Valparaiso University, Valparaiso, Ind. H. C. Hesse, C. E. Peller.

KEITH, CHARLES, Instructor in Industrial Arts, Kent State University, Kent, Ohio. P. E. Machovina, R. S. Paffenbarger.

KELLY, FREDERICK L., JR., Instructor in Engineering Drawing, University of Alabama, University, Ala. J. A. Bennett, W. H. Taylor.

KIPP, JOHN E., Instructor in Applied Mechanics, University of Kansas, Lawrence, Kansas. T. V. Nemecek, K. C. Deemer.

LOVERIDGE, LAWRENCE E., Instructor in Physics, Newark College of Engineering, Newark, N. J. A. J. Manock, M. R. Weller.

MANTELL, CHARLES L., Professor of Chemical Engineering, Newark College of Engineering, Newark, N. J. G. B. Thom, G. C. Keefe.

MARBOE, ROBERT F., Manager of Engineering Services Division, Ordnance Research Laboratory, Pennsylvania State University, State College, Pa. A. Addison, A. T. Thompson.

MARTIN, GEORGE H., Lecturer in Mechanical Engineering, Northwestern University, Evanston, Ill. R. L. Young, D. D. Kilner.

MCGLOTHLAN, JOHN A., Instructor in Mechanical Engineering, University of Denver, Denver, Colo. W. Parks, A. Krill.

MORTIMER, KENNETH, Associate Professor of Civil Engineering, Valparaiso University, Valparaiso, Ind. H. C. Hesse, C. E. Peller.

NELSON, HANS P., Instructor in Engineering Drawing, Wayne University, Detroit, Mich. R. T. Northrup, R. W. Grant.

PAN, SAI-LUNG, Assistant Research Professor of Civil Engineering, Manhattan College, New York, N. Y. O. Ondra, Brother J. McCabe.

PERRON, CHARLES H., Assistant Instructor in Civil Engineering, Newark College of Engineering, Newark, N. J. W. S. LaLonde, Jr., J. M. Robbins.

PUGH, WALTER H., Instructor in Engineering, Pittsburgh Technical Institute, Pittsburgh, Pa. B. R. Teare, Jr., J. R. Jackson.

RAMSAUR, JOHN C., Instructor in Mechanical Engineering, Louisiana Technical Institute, Ruston, La. L. R. Daniel, Jr., J. G. Chumley.

RENOUD, HARRY R., Head of Mathematics Department, Reedley Junior College, Reedley, Calif. B. M. Green, H. H. Wheaton.

RISSER, ARTHUR C., Assistant Professor of Engineering Drawing, University of Wichita, Wichita, Kans. M. H. Snyder, Jr., J. W. Dunn.

RYSKIEWICH, BERNARD S., Instructor in Engineering Drawing, New York University, New York, N. Y. I. Wladever, L. O. Johnson.

SHANAHAN, ROBERT J., Assistant Professor of Engineering Drawing, University of Notre Dame, Notre Dame, Ind. H. P. Ackert, W. W. Turner.

SHERRILL, ALVAN C., Assistant to Works Manager, Columbia-Southern Chemical Corporation, Barberton, Ohio. H. O. Croft, A. A. Pringle.

SHEWAN, WILLIAM, Assistant Professor of Electrical Engineering, Valparaiso University, Valparaiso, Ind. H. C. Hesse, C. E. Peller.

SHIRK, RICKLEF, W., Staff Assistant, Chrysler Institute of Engineering, Detroit, Mich. W. L. David, L. R. Baker.

SMITH, HENRY H., Assistant Professor of Physics, Newark College of Engineering, Newark, N. J. A. J. Monock, M. N. Mainardi.

SMITH, PHILIP A., Professor of English, Rensselaer Polytechnic Institute, Troy, N. Y. F. Abbuhl, S. P. Olmsted.

SPERRY, CLAUDE J., Jr., Assistant Professor of Electrical Engineering, Tulane University, New Orleans, La. C. W. Ricker, D. H. Vliet.

SWIFT, ROBERT G., Engineering School Supervisor, Bell Telephone Company of Pennsylvania, Philadelphia, Pa. J. G. Brainerd, S. R. Warren.

UBAN, EARL C., Assistant Professor of Civil Engineering, Valparaiso University, Valparaiso, Ind. H. C. Hesse, C. E. Peller.

URBAN, MOSES W., Professor of Mechanical Engineering, Valparaiso University, Valparaiso, Ind. H. C. Hesse, C. E. Peller.

WARNICK, CALVIN C., Associate Research Professor of Civil Engineering, University of Idaho, Moscow, Idaho. L. B. Craine, D. S. Hoffman.

WETTERSTROM, EDWIN, Assistant Professor of Civil Engineering, University of Missouri, Columbia, Mo. M. M. Bolstad, R. H. Luebbers.

WILLIAMS, J. FRED, JR., Associate Professor of Metallurgical Engineering, State College of Washington, Pullman, Wash. J. P. Spielman, C. L. Baker.

322 new members elected this year

In the News

The **National Academy of Sciences-National Research Council** has been asked by officials of both industry and Government to establish within the Academy-Research Council framework a committee to concern itself with the common interests and relationships of industrial and governmental research, particularly in the area of applied research.

Conferences between industrial and governmental research executives and directors, called by the Academy-Research Council, recommended that a small committee be organized to explore the need for better acquaintance and understanding between Government and industry research leaders, and to consider methods for accomplishing this objective. As a result, the Government-Industry Research Committee has been organized by the Academy-Research Council with the following membership:

Edgar C. Bain, United States Steel Corporation, Chairman
Allen V. Astin, National Bureau of Standards
D. P. Barnard, Deputy Assistant Secretary of Defense, Research and Development
Ralph Bown, Bell Telephone Laboratories, Inc.
Ralph Connor, Rohm and Haas Company
Hugh L. Dryden, National Advisory Committee for Aeronautics
Paul D. Foote, Gulf Research and Development Company
G. E. Hilbert, Agricultural Research Service, U. S. Department of Agriculture
Randolph Major, Merck and Company, Inc.
Roy C. Newton, Swift and Company
Alan T. Waterman, National Science Foundation

At its first meeting the Committee concluded that effective mechanisms already exist in many fields for furthering mutually helpful relations between government and industry research. However, the Committee agreed to hold itself available as necessary to assist in exchanging views and ideas designed to improve such relations where either Government or industry groups may feel this to be desirable.

When its services are requested, the Committee proposes to consider first the extent to which the need can be satisfied by existing mechanisms. If appropriate, the Committee will then consider designation of an *ad hoc* group of individuals active in the particular field concerned to assist in bringing about improved understanding and closer relationships between Government and industry people in that field.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Bucknell University	April 29–30, 1955	W. D. Garman, Bucknell University
Illinois-Indiana	University of Notre Dame	May 21, 1955	G. E. Ellithorn, University of Notre Dame
Kansas-Nebraska	University of Nebraska	Oct. 22–23, 1955	G. W. Bradshaw, University of Kansas
Michigan	Michigan State College	May 7, 1955	C. C. Sigerfoos, Michigan State College
Middle Atlantic	Swarthmore College	May 7, 1955	H. N. Jenkins, Swarthmore College
Missouri-Arkansas	University of Missouri	March 26, 1955	M. M. Jones, University of Missouri
National Capital Area	Catholic University	Oct. 5, 1954	J. C. Michalowicz, Catholic University
New England	Massachusetts Institute of Technology	Oct. 9, 1954	E. R. McKee, University of Vermont
North Midwest	Michigan College of M. and T.	Oct. 8–9, 1954	C. J. Pratt, Michigan College of M. and T.
Ohio	A.F. Inst. Wright	Sept. 17–18, 1954	K. F. Sibila, University of Akron
	University of Akron	May 7, 1955	
Pacific Northwest	University of Idaho	April 15–16, 1955	M. L. Jackson, University of Idaho
Pacific Southwest	University of California, Berkeley	Dec. 28–29, 1954	B. M. Green, Stanford University
Rocky Mountain	Colorado A. & M. College	April 16, 1955	D. F. Peterson, Colorado A. and M. College
Southeast	University of Tennessee	April 14–16, 1955	H. V. Flinsch, Mississippi State College
Southwest	University of Oklahoma	April 8–9, 1955	V. L. Doughtie, University of Texas
Upper New York	Cornell University	Oct. 22–23, 1954	N. A. Christensen, Cornell University

Members of the Society are welcome at all Section Meetings

Teaching Positions Available

The following rules were adopted by the General Council of the ASEE:

The privilege of advertising for teaching positions is extended only to colleges and technical institutes which are either Active or Affiliate Institutional Members of the ASEE. Advertisements must be for positions available only. No advertisements will be accepted for an individual seeking a job.

Advertisements must be submitted not later than the first day of the month preceding the month of issue. Because of limited staff, the ASEE headquarters cannot maintain personnel files or supply detailed information about jobs. In replying to blind ads, address letters to American Society for Engineering Education, Northwestern University, Evanston, Illinois and give blind ad number. Information and rates for advertising in the Journal can be received by writing ASEE Headquarters. In order to conserve space and achieve uniformity, the privilege is reserved to rearrange advertisements.

INSTRUCTOR IN ELECTRICAL ENGINEERING on or before February 1, 1955: One familiar with electric power and electronics; preferably some industrial experience. Good opportunity for advancement. Franklin Technical Institute, 41 Berkeley Street, Boston 16, Mass.

AN INSTRUCTOR IN ENGINEERING Drafting and Machine Design on or before February 1, 1955: One thoroughly familiar with theory and practical design who has had some industrial experience. Opportunity for advancement. Franklin Technical Institute, 41 Berkeley Street, Boston 16, Mass.

ASSISTANT PROFESSOR—TO TEACH Dynamics, Fluid Mechanics, Vibrations, engineering analysis. At least a master's degree and some industrial experience preferred. Apply to Louis Slegel, Department of Mechanical Engineering, Oregon State College, Corvallis, Oregon.

INSTRUCTOR IN MECHANICAL ENGINEERING to teach Laboratory and Lecture courses in the Heat-Power field. Start now or later. Salary depends on qualifications. Apply to: Prof. J. W. Bunting, Department of Mechanical Engineering, University of Cincinnati, Cincinnati 21, Ohio.

INSTRUCTOR FOR INDUSTRIAL ELECTRONICS Department of a New England Technical Institute. B.S. Degree with industrial or teaching experience desired. Position open September 1, 1955. Apply to: Head, Industrial Electronics Department, Wentworth Institute, Boston, Mass.

ENGINEERING TEACHERS. ELECTRICAL—Circuits, Machines, Electronics. Civil—surveying and strength of materials. Mechanical—thermodynamics and heat-power. Drawing—drawing, descrip. geom., and design. M.S. degree plus industrial experience reqd. Excellent opportunities in young department for instructor or assistant professor with interest in teaching. New bldg. and equipt. Good salary scale. San Jose State College, San Jose, California.

RESEARCH ASSISTANTS AND INSTRUCTORS (part-time and full-time) for teaching and research in Engineering Mechanics. Opportunity to study for the M.S. or Ph.D. degrees. Apply to: Professor J. Marin, Head, Department of Engineering Mechanics, The Pennsylvania State University, State College, Pennsylvania.

ACTING HEAD OR HEAD, CIVIL ENGINEERING. Familiar with current undergraduate curricula and cooperative plan. Prepared to teach Soil Mechanics, Structures and Surveying. Twelve month appointment open September, 1955. Address Dean of Engineering, The University of Akron, Akron 4, Ohio.

CHRYSLER INSTITUTE OF ENGINEERING

again has openings on its full time teaching staff. They are:

1. **Supervisor of engineering graduates working on individual automotive design projects as a part of their Graduate School course. Duties would also include supervision of graduate classwork.**

   Desired qualifications: Age 25–40; BS degree or higher in engineering; at least 2 years of college teaching experience; some design experience, preferably automotive.

2. **Teacher and supervisor of Graduate School classwork. Qualifications: Age 25–40; MS degree in engineering; experience in teaching mechanical engineering subjects.**

Please write to—

CHRYSLER INSTITUTE OF ENGINEERING
Attn: L. R. Baker, Director
P. O. Box 1118
Detroit 31, Michigan

ASEE Catalog of Learning Aids

Civil Engineering **Electrical Engineering**

Mechanical Engineering **Engineering Mechanics**

Mathematics

Prepared by the ASEE Committee on Teaching Aids. Over 5000 teaching aids have been reviewed. The catalog lists 290 aids which are rated by the ASEE reviewing committees as the best available learning aids for engineering education. The catalog summarizes the content of each aid, recommends the course for which it is best adapted, gives details of physical size, equipment necessary, where it can be obtained, cost and other pertinent data.

This catalog will direct you by the most expeditious route to those teaching aids which will add a new dimension to your teaching. Send for one today.

This project was financed by contributions from industry to defray the traveling expenses of the reviewing committees and to make it possible to carry this on as a continuing project of ASEE.

Send remittance to

Price $1.00

American Society for Engineering Education, University of Illinois, Urbana, Illinois

College Notes

Colleges and universities throughout the country have been invited by the **University of Minnesota** to send delegates to the Second National Conference on Campus Safety to be held at the University April 18–20, 1955. At the first conference, held last year at the University of Illinois, 28 institutions from various parts of the country were represented.

The conference is aimed at a nation-wide exchange of ideas on specific problems to be met in promoting the safety of students and employees. "Fire Safety" will be discussed by Professor John J. Ahern, Illinois Institute of Technology. Fred R. Ingram of University of California will treat campus occupational health problems. Professor William E. Cox of Georgia Institute of Technology is scheduled to talk on the integration of safety into the general curriculum.

Safety standards for off-campus housing, protecting one-third of the University of Minnesota's 20,000 students, will be described by Richard G. Bond of the Students' Health Service of the University. The part of sound architecture in the safer campus will be handled by Otto Teegan, State University of New York. Other talks will concern traffic safety and parking problems, intramural athletics, radiation safety, shop and laboratory areas, and the special problems of the agricultural campus.

The conference is sponsored jointly by the University of Minnesota and the National Safety Council. All sessions will be held on the Minneapolis campus, at the Center for Continuation Study, a self-contained college with complete conference facilities, including eating and sleeping accommodations.

As a part of the Centennial Year celebration at **Michigan State College**, the College of Engineering is sponsoring a symposium on the topic, "Automation —Engineering for Tomorrow" on May 12–14, 1955. The program is designed to attract engineers, executives, educators and others interested to the campus. In order to appeal especially to practicing engineers with specialized interests, separate programs for the several branches of engineering have been planned, with all of the groups meeting together for certain general sessions. Professor J. M. Apple is Chairman of the symposium.

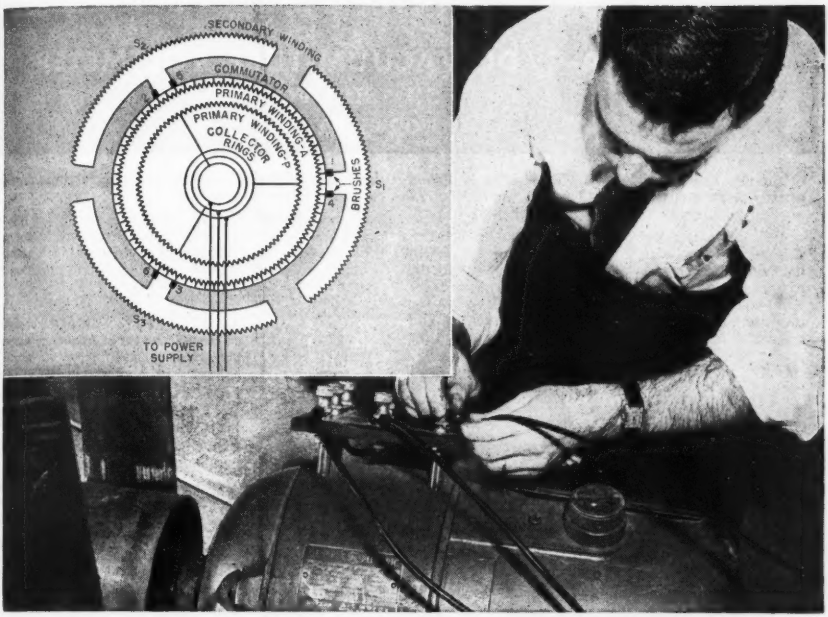
The Ninth Annual Industry-Faculty Conference at **Louisiana State University** will be held March 31–April 1, 1955. The theme of the conference this year is "The Engineering School, the Engineer and Industrial Development." Speakers at the conference will include Dean N. W. Dougherty, ASEE President; Mr. J. N. Gorringe, Esso Standard Oil Co.; Dr. Frank Soday, Chemstrand Corp. For further information write to J. W. Brouillette, Director, General Extension Division, Louisiana State University, Baton Rouge 3, La.

ANNUAL MEETING

June 20-24, 1955

Pennsylvania State University

STATE COLLEGE, PA.



More than 14 basic laboratory experiments demonstrated with versatile G-E ACA motor

Compared to wound rotor motors, G-E's a-c adjustable speed motor provides:

- Greater range of speed adjustment
- Higher efficiency and power factor over most of the speed range
- Speed regulation of shunt-wound d-c motor

Typical of many engineering schools, Rensselaer Polytechnic Institute includes tests of these and other characteristics of the ACA motor in their senior laboratory. Students thus become familiar with an important motor used in industry and with its design characteristics.

Tests of the ACA motor can also be made to show the characteristics of an adjustable speed motor with series characteristics; a single-phase repulsion motor; a self-driven frequency changer; a self-exciting synchronous generator; and other types of motors and generators.

For further information on the G-E educational ACA motor contact your nearest G-E Apparatus Sales Office. Or write for Bulletin GEC-740 to General Electric Co., Section 688-1, Schenectady 5, New York.

Progress Is Our Most Important Product

GENERAL ELECTRIC

NEW A-C/DC VACUUM-TUBE VOLTMETER

0.1-1500 VOLTS AC
0.02-500 VOLTS DC

The new G-R Type 1803-B VTVM is an improved version of the well known "A" model, popular for its accuracy, convenience in use and reliability.

This instrument will measure a-c voltages between 0.1 and 150 volts with a basic accuracy of 3%. With the 10:1 multiplier, now permanently attached to the cabinet, direct-reading measurements can be made to 1500 volts. A distinct new feature is the provision for measuring d-c voltages from 0.02 to 500 volts. With this added facility, this voltmeter becomes as useful for every-day laboratory work as the more elaborate models available at much greater cost.

The Type 1803-B Vacuum-Tube Voltmeter has a single zero adjustment — continual resetting is not required when switching from one voltage scale to another. For greatest accuracy, four meter scales are provided to cover the five ranges.

Type 1803-B
Vacuum-Tube
Voltmeter
$180.00

A-C ACCURACY: ±3% of full scale on all ranges, subject to frequency correction (curve supplied) above 50 Mc; additional ±1% error with multiplier

D-C ACCURACY: ±3% of full scale for 1.5, 5, 15, and 50-volt ranges; ±4% of full scale for 150 and 500-volt ranges

GOOD FREQUENCY RESPONSE: Resonant frequency is 410 Mc

A-C INPUT IMPEDANCE: 7.7 meg ohms in parallel with 11.5 μμf; parallel resistance decreases at higher frequencies

D-C INPUT IMPEDANCE: 111 meg ohms; open-grid input can be obtained for 1.5 to 50-volt ranges by unsoldering internal connection

COMPLETELY SHIELDED PROBE: contains twin diode; one section for rectifying a-c voltage under measurement, other half for balancing out effects of transients and line-voltage changes on first tube. Probe plugs into 1:1 or 10:1 jacks under multiplier box, making for neat appearance and convenience in transit

POLARITY SWITCH: permits voltages of either + or − polarity to be applied to the high input terminal

INTERNAL CALIBRATION CONTROL: a-c and d-c calibration easily corrected if tube is changed

CORD STORAGE: probe cable conveniently stores within instrument housing

SMALL-LIGHT WEIGHT: only 9½ lbs.

ACCESSORIES SUPPLIED: Type 274-MB Double Plug, 2 test leads, 2 test prods, 2 alligator clips

WE SELL DIRECT—Prices are net, FOB Cambridge or West Concord, Mass.

GENERAL RADIO Company

275 Massachusetts Avenue, Cambridge 39, Massachusetts, U.S.A.

90 West Street NEW YORK 6
9035 13th St., Silver Spring, Md. WASHINGTON, D.C.
920 S. Michigan Avenue CHICAGO 5
1000 N. Seward Street LOS ANGELES 38

1915-1955
40 Years of Pioneering
in Electronics

ELECTRONICS...

easy to teach ...easy to learn

with the New, LOW COST

Crow Basic Electronics Kit...Model 50-A

YOU TEACH BY VISUAL EXPERIMENT –YOUR STUDENTS LEARN BY DOING

● Here's another important "first" from Crow Electri-Craft—electronics by *visual experiment!* This unique new kit is designed for students who have completed the Beginners' Electricity course with Crow Electri-Kit Model 41-B or equivalent training. It permits them to advance immediately into the study of electronics. They learn by *doing;* that is, they verify electronic principles by building their own operating assemblies . . . the most fascinating and effective instruction method ever devised.

Model 50-A contains 82 precision-made components—everything needed to perform 60 experiments in electronic fundamentals. A 275-page, illustrated manual in worksheet form is also included. It guides students step-by-step . . . shows what parts are needed for each assembly, how to set it up, and how the theory involved is put to practical use.

This Basic Kit provides a solid foundation for further training in specialized electronic fields—**Radio Transmitting and Receiving, Industrial Electronic Circuitry, or Basic Radar and Television Circuitry.** All of these principles are covered in the Crow Electronic Tubes, Circuits and Devices Kit (Model 53) available soon.

60 Operating Assemblies

Capacitors • Voltage Dividers • Vibrators Frequency Discriminators • Filters Frequency Multipliers • Resonant Circuits Electrical Indicating Instruments Rectifiers • Fly-back Voltage Supply Principles

Crow Basic Electronics Kit Model 50-A
82 parts including precision meter (±1%), precision resistors, coils, potentiometer, rectifiers, capacitor bank, etc., plus 275-page manual. All parts mounted for use with "Kwik-Klip" solderless connectors. Supplied in sturdy corrugated case.....$37.50

Hardwood Carrying Case
For Model 50-A. Has pegboard top and slip hinges. Can be used as baseboard for experiments.....$8.75

Crow Basic Electronics Kit Model 50-B
For those who already own Model 41-B Electri-Kit. Same as Model 50-A (above) with all 41-B components omitted...$37.50

Write for bulletin describing CROW Basic Electronics Kit Model 50-A.

BUILD YOUR ELECTRICAL AND ELECTRONIC COURSES AROUND CROW EQUIPMENT

CROW ELECTRI-CRAFT CORP.

Division of Universal Scientific Co., Inc.
Box 338H, Vincennes, Indiana

Boeing offers long-range engineering careers

Scores of Boeing engineers today are enjoying intriguing and rewarding careers because of sound advice given them 10, 15 or 20 years ago by their college professors and placement officers.

Today your students will find in aviation—and Boeing—still greater opportunity and growth potential.

Boeing today employs more engineers than at the peak of World War II. One out of each seven employees is an engineer! And stability has long marked an engineering career here. Forty-six per cent of Boeing engineers have been with the company for more than five years; 25% for more than 10 years; 6% more than 15 years. There are a number with 20, 25 and even 30 years' service.

What kind of work does Boeing offer? Opportunity lies in three basic areas: Research, Design and Production. Programs include multi-jet bombers, America's first jet transport, the Bomarc pilotless aircraft guided missile system; application of nuclear power and supersonic flight.

Boeing is continually seeking engineers of ability—electrical, civil, mechanical, aeronautical and related fields, as well as physicists and mathematicians with advanced degrees.

Engineers are encouraged to take daytime graduate studies during working hours and are reimbursed for all tuition expenses. May we send you—or any of your students—additional information about engineering careers at Boeing? Just write:

JOHN C. SANDERS, *Staff Engineer—Personnel,*
Boeing Airplane Company, Seattle 14, Wash.

BOEING

Unexcelled Opportunities

FOR YOUR GRADUATES

As a leading manufacturer in four great basic industries, a builder of scores of types of equipment, a seller of more than 1600 products—Allis-Chalmers offers training unmatched in scope . . . opportunities in over 90 different training locations.

ALLIS-CHALMERS offers graduates a chance to explore their own aptitudes and inclinations . . . discover by doing, the work they like best.

They can study any one of many diverse types of equipment including: power generation, distribution and utilization apparatus . . . mining or cement-making machinery . . . food or chemical processing equipment . . . atomic energy . . . and general manufacturing. They can specialize in design, production, sales, research, installation or service.

For details on the Allis-Chalmers graduate training course, talk with the A-C representative who will be visiting your campus . . . contact the nearest A-C District Sales Office . . . or write, Graduate Training Section, Allis-Chalmers, Milwaukee 1, Wisconsin.

Trainees get classroom, shop and field experience . . . have close personal contact with top-flight, nationally recognized experts in their proposed line of work.

QUICK FACTS

1. THE COURSE: Established in 1904, it's recognized today as one of the most comprehensive, most workable programs of its kind.

2. ITS OPERATION: Covers a maximum of 24 months. Counselors help trainees plan their courses; are always available for personal guidance.

3. ITS OPTIONS: Trainee selects own course. If his interests change, he can alter his course.

4. ITS OBJECTIVES: The program is designed to put the right man in the right job, to develop men of management potential. Many members of today's management are graduates.

ALLIS-CHALMERS

C-5679

HARPER

Recent Successful Texts for Engineers

ENGINEERING MECHANICS, *Second Edition*
By FERDINAND L. SINGER. 525 pages..... $6.00
Completely revised in 1954, immediately adopted by more than 100 institutions.

STRENGTH OF MATERIALS
By FERDINAND L. SINGER. 469 pages..... $5.50
The unquestioned leader in its field.

INTRODUCTION TO HYDRAULICS AND FLUID MECHANICS
By J. O. JONES. 403 pages..... $6.00
A sound basic text for civil and mechanical engineers, designed for students who take only one course in the subject.

ENGINEERING THERMODYNAMICS
By SHORT, KENT, and TREAT. 467 pages.... $6.00
A new, thorough, basic text for junior-level courses, unusually teachable and practical.

EXPERIMENTS IN ELECTRONICS AND COMMUNICATION ENGINEERING, *Second Edition*
By SCHULZ, ANDERSON, and LEGER. 342 pages. $6.00
A thorough revision, designed for college classes, of a long-time favorite text for laboratory courses in electronics.

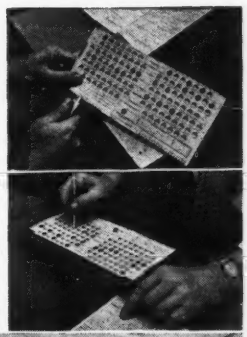
DIFFERENTIAL EQUATIONS WITH APPLICATIONS
By BETZ, BURCHAM, and EWING. 309 pages. . $4.50
A new text especially suitable for engineers because of its unusually extensive and successful integration of theory and applications.

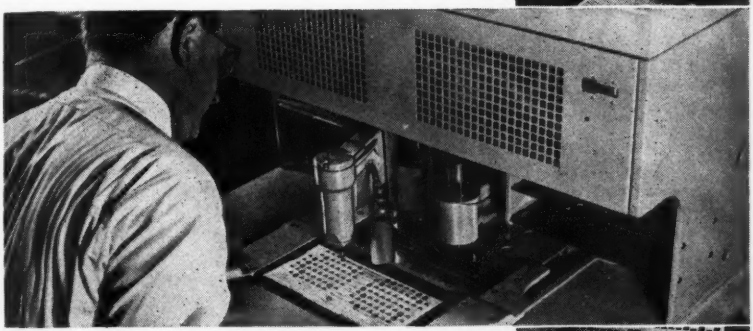
And Ready in March

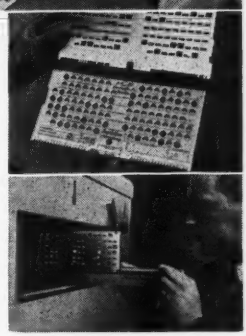
TRANSFORM CALCULUS, *With an Introduction to Complex Variables*
By E. J. SCOTT. 330 pages..... $7.50
An outstanding new text for courses centering around the Laplace Transform and requiring a thorough understanding of complex variables.

HARPER & BROTHERS, 49 East 33d Street, New York 16

How your telephone call asks directions... and gets quick answers







When the Bell System's latest dial equipment receives orders to connect your telephone with another in a distant city, it must find—quickly and automatically—the best route.

Route information is supplied in code — as holes punched on steel cards. When a call comes in, the dial system selects the appropriate card, then reads it by means of light beams and phototransistors. Should the preferred route be in use the system looks up an alternate route.

It is a simple matter to keep thousands of cards up to date when new switching points are added or routing patterns are changed to improve service. New cards are quickly and easily punched with the latest information to replace out-of-date cards.

This efficient, flexible way of keeping your dial system up to the minute was devised by switching engineers of Bell Telephone Laboratories, who are continually searching for ways to improve service and to lower costs. Right now most of the Long Distance dialing is done by operators, but research is hastening the day when you will be able to dial directly to other telephones all over the nation.

Perforated steel cards, which give directions to the Long Distance dial telephone system, are easy to keep up to date. New information is clipped (1) and punched (2) by hand on a cardboard template. This guides the punch-press that perforates a steel card (3), and the two are checked (4). The new card is put into service in the card translator (5).

BELL TELEPHONE LABORATORIES

Improving telephone service for America provides careers for creative men in scientific and technical fields.

Coming in April . . .

A book that has a definite place wherever *functional* mathematics is taught or used . . .

MATHEMATICS AND MEASUREMENTS

by Merrill Rassweiler, *Associate Professor of Physical Science and Mathematics, The General College, University of Minnesota;* and J. Merle Harris, *Assistant Professor of Natural Sciences, The General College, University of Minnesota*

A program of fundamental mathematics for use in practical measurement situations . . .

—bridges the gap between traditional mathematics and the use of mathematics as a working tool

—focuses on the development of mathematical skills required in laboratory, shop, and field

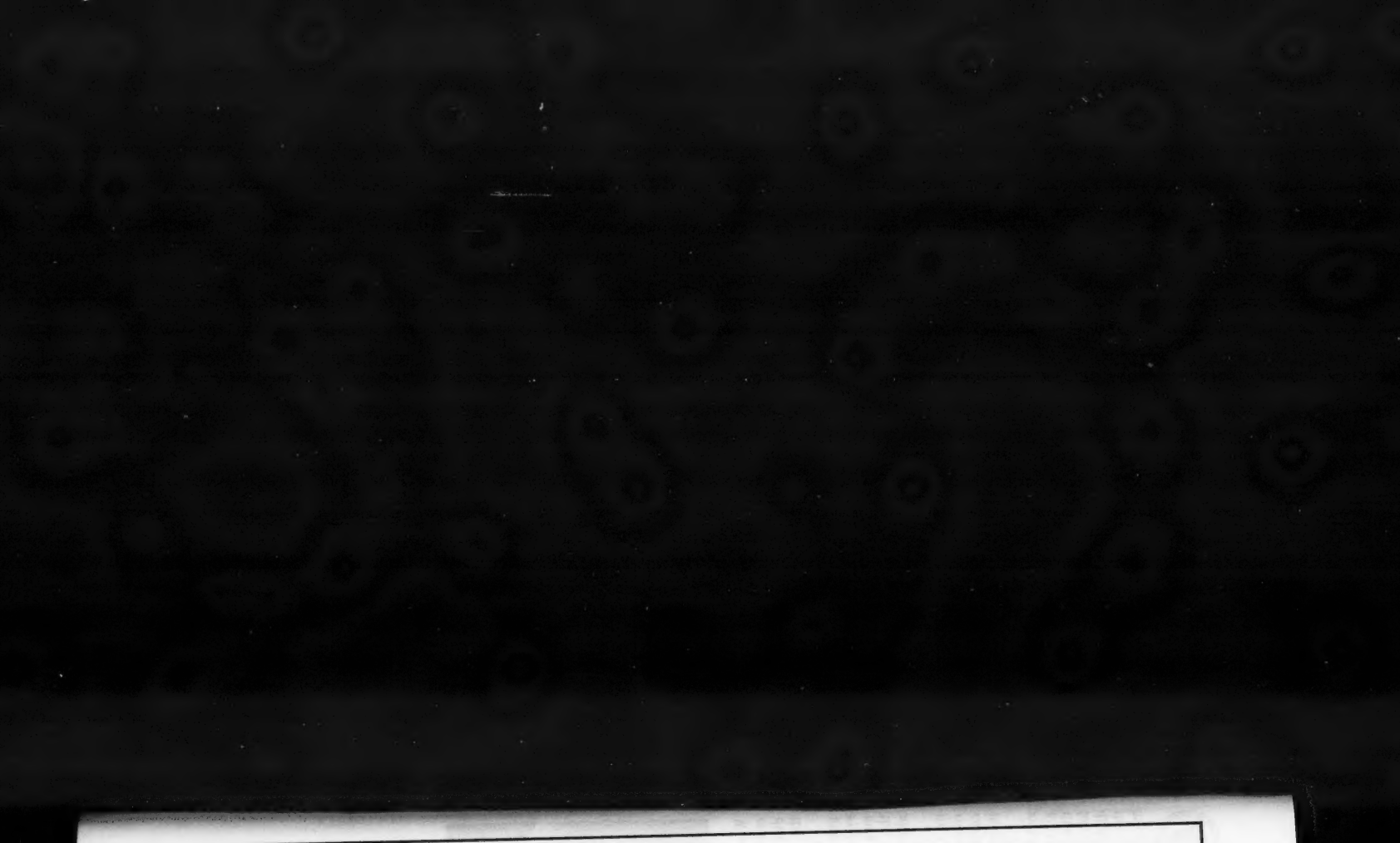
—provides extensive practice and experience in the application of basic mathematics principles to the solving of measurement problems.

Note: This book is an outgrowth of a general education course successfully developed and taught by the authors to satisfy the needs of students who have *not* had any high school mathematics as well as for those who have.

WATCH FOR APRIL ISSUE!

Row, Peterson and Company

Evanston, Ill. White Plains, N. Y.



VAN NOSTRAND FOR COLLEGE TEXTS

Have you Examined?

MICROWAVE THEORY AND TECHNIQUES

By REICH, ORDUNG, KRAUSS and SKALNIK

This new comprehensive text emphasizes the theory and applications of microwave tubes and circuits. It covers most of the recent advances in this rapidly developing field. The book further includes: the use of standard symbols wherever possible; approximately 600 illustrations, graphs, and charts, problems with answers; laboratory experiments; numerous cross-references; and a symbol index. Prepared primarily for senior or first-year graduate courses to include recitation and laboratory, this compendious work will also be welcomed by research workers and practicing engineers as a valuable reference book.

901 pages (1953) College Edition $10.00

ENGINEERING MECHANICS, 2nd Ed.

By COX and PLUMTREE

This new work is designed for students majoring in all branches of engineering. There has been a substantial rearrangement of subject matter, the coverage of topics has been enlarged in many instances, and the number of problems has been increased materially. Teachers and students alike will find this new edition well organized, better balanced, authoritative, novel and original in treatment, and logical in its development of basic ideas. A PROBLEM SOLUTIONS BOOK IS AVAILABLE to accompany this text.

392 pages (1954) $5.50

DWELLING HOUSE CONSTRUCTION
2nd Edition

By ALBERT G. H. DIETZ

This new edition, although largely rewritten to include the latest trends in the field, continues to present the details of established methods of construction in the same peerless fashion. New material on panelized construction and expanded coverage of hardware have been incorporated in this latest edition.

408 pages (1954) College Edition $5.50

D. VAN NOSTRAND COMPANY, INC.
Publishers Since 1848
250 FOURTH AVE.
NEW YORK, N.Y.

Send for copies on approval

New McGRAW-HILL Books

PRINCIPLES OF METAL CASTING

By RICHARD W. HEINE and PHILIP C. ROSENTHAL, University of Wisconsin; in cooperation with the Textbook Committee of the Education Division, American Foundrymen's Society. Ready for fall classes.

A textbook for teaching metal casting in engineering colleges and departments. It is a thorough treatment of the subject, and can be used either for the general foundry processes survey course or the more detailed technical course in basic foundry metallurgy. No processes other than metal casting are considered. Sample problems and calculations, tables, graphs, line diagrams, photographs, etc., are used to illustrate the principles.

ELEMENTARY PLANE SURVEYING. New Third Edition

By RAYMOND E. DAVIS, University of California, Berkeley. 524 pages, $5.50

A combined text and field manual, noted for its concise yet comprehensive treatment of both theory and practice, its carefully chosen material, and its excellent forms of field notes. Ideal for shorter courses usually offered for non-civil engineering students, it presents all the more important and commonly used features of the subject, but at the same time avoids the advanced problems. All material is completely revised and brought up to date.

MOTION AND TIME STUDY

By GERALD NADLER, Washington University, St. Louis, Missouri. Ready for fall classes

This book sets forth an operating procedure found to be highly successful in all types of motion and time study work. There is a detailed presentation of new techniques and adaptations along with old techniques. The problems which have been facing, and still face, motion and time study practitioners are presented; their effect on concept and practice is detailed, and solutions are given where possible. Concepts, drawn from all industries, are interspersed with practical illustrations to show how techniques can be adapted and changed to meet individual needs.

ELEMENTS OF HYDRAULIC ENGINEERING

By RAY K. LINSLEY and JOSEPH B. FRANZINI, Stanford University. *McGraw-Hill Civil Engineering Series.* Ready for fall classes

A basic textbook for senior civil engineering students. It presents a concept of a unified field of hydraulic engineering based throughout on a common groundwork of fundamentals. The book is divided roughly into three parts: Part I deals with the hydrologic and legal aspects common to almost all projects; Part II discusses the structures required for hydraulic projects; Part III discusses the special problems encountered in hydraulic projects.

Send for copies on approval

McGRAW-HILL BOOK COMPANY, INC.

330 West 42nd Street - New York 36, N. Y.